ANSI/RESNET 301-2014

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

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P.O. Box 4561
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SPECIAL NOTE

This ANSI/RESNET Standard is a voluntary consensus standard developed under the auspices of the Residential Energy Services Network (RESNET) in accordance with RESNET's *Standards Development Policy and Procedures Manual,* Version 1.1, January 2, 2012. Consensus is defined by the American National Standards Institute (ANSI), of which RESNET is a member, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrance of more than a simple majority but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory.

RESNET obtains consensus through participation of it national members, associated societies, and public review.

This Standard is under continuous maintenance. In accordance with Section 10.9 of the *RESNET Standard Development Policy and Procedures Manual,* continuous maintenance proposals should be submitted to the Manager of Standards.

The Manager of Standards should be contacted for:

a. Interpretation of the contents of this Standard
b. Participation in the next review of the Standard
c. Offering constructive criticism for improving the Standard
d. Permission to reprint portions of the Standard

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Contents

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Forward (Informative)

This Standard provides a consistent, uniform methodology for evaluating and labeling the energy performance of residences. The methodology compares the energy performance of an actual home with the energy performance of a reference home of the same geometry, resulting in a relative energy rating called the HERS Index. Where the energy performance of the actual home and the reference home are equal, the HERS Index is 100 and where the actual home requires no net purchased energy annually, the HERS Index is 0 (zero).

The HERS Reference Home used for this comparative analysis has the energy attributes of the 2006 International Energy Conservation Code (IECC) *Standard Reference Design*. Thus, the HERS Index is relative to the minimum building energy efficiency requirements of the 2006 IECC. As a result, the HERS Reference Home performance will not comport with state or local building codes that differ in stringency from the 2006 IECC. Where local building energy codes are less stringent than the 2006 IECC, the HERS Index for the local standard will be greater than 100 and where local building energy codes that are more stringent than the 2006 IECC, the HERS Index for the local standard will be less than 100. Because the HERS Index Score accounts for all lighting, appliances and miscellaneous energy loads, there is never a 1-to-1 correspondence between code compliance (even under the 2006 IECC) and a HERS Index Score of 100.

This Standard contains both normative and informative material. The body of the Standard is normative and must be complied with to conform to the Standard. Informative materials are not mandatory and are limited to this forward, footnotes, references and annexes, all of which are clearly marked as informative.

1. Purpose. The provisions of this document establish residential energy rating and labeling Standards, consistent with the provisions of the Energy Policy Act of 1992, which provide for uniformity and consistency in the rating and labeling of such buildings.

2. Scope. This standard is applicable to all one- and two-family dwellings and to dwelling units in residential buildings not over three stories in height above grade containing multiple dwelling units.

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]

3.1. General. Unless stated otherwise, the terms and words in Section 3.2 shall have the meanings indicated therein. Words used in the present tense include the future, words in the masculine gender include the feminine and neuter, and singular and plural are interchangeable. Terms not defined in Section 3.2 shall have ordinary accepted meanings such as the context implies.

3.2. Definitions.

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).

Annual Fuel Utilization Efficiency (AFUE) **–**a measure of the efficiency of gas or oil fired furnaces and boilers calculated as the furnace heating energy output divided by fuel energy input. AFUE does not include electrical energy for fans, or electronic ignition systems (see also Electric Auxiliary Energy).

Approved – shall mean approved by an entity adopting and requiring the use of this Standard as a result of investigation and tests conducted by the entity or by reason of accepted principles or tests by nationally recognized organizations.

Approved Rating Provider – An approved 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.

Approved Software Rating Tool [2] – A computerized procedure that is approved for the purpose of conducting home energy ratings and calculating the annual energy consumption, annual energy costs and a HERS Index for a home.

Approved Tester – An individual who, by virtue of training and examination, has demonstrated competence in the performance of on-site testing in accordance with Sections 802 and 803 of the *Mortgage Industry National Home Energy Rating Systems Standards* and who has been approved by an Approved Rating Provider to conduct such tests.

Auxiliary Electric Consumption – The annual auxiliary electrical energy consumption for a fossil fuel fired furnace, boiler or ground source heat pumps in kilowatt-hours per year.

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

[2] (Informative Note) A list of RESNET approved software rating tools meeting the requirements of RESNET Publication No. 13-002 is online at http://www.resnet.us/professional/programs/energy_rating_software.

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 of floor area 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 of floor area or greater or other similar rooms shall count as a Bedroom, but living rooms and foyers shall not.

Biomass Fuel – Plant or animal waste materials that have been processed to be capable of providing useful heat through combustion.

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.

Certified Rater – An individual who has become qualified to conduct home energy ratings through certification by an Approved Rating Provider.

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.

Conditioned Floor Area (CFA) – The projected floor area of the Conditioned Space within a building, measured in accordance with ANSI Standard Z765-2012 except that, unlike the Ceiling Height Requirements of ANSI Standard Z765, portions of the finished floor area that have a height of less than 5 feet shall be included in the Conditioned Floor Area.

Conditioned Space [3] **–** An area or room within a building serviced by a space heating or cooling system designed to maintain space conditions in accordance with Section 4.2 of this Standard.

Conditioned Space Boundary – The principal air containment planes of a building that separate the Conditioned Space within the building from the outdoor environment or from Unconditioned Space.

Design Approval Primary Inspection Agency (DAPIA) – 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

[3] (Informative Note) Conditioned Space represents the *simulation control volume* that is mechanically controlled to specified conditions (68 F for heating and 78 F for cooling) and on which an energy balance is performed by the simulation software.

the source of the load, such as energy losses associated with heat transfer across duct or piping walls and air leakage to or from forced air distribution systems.

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.

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.

Glazing – Sunlight-transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing area 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 of 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.

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 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 annually.

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 Approved Rating Providers, as specified in these Standards.

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.

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

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.

Kilowatt-hour (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.

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 an Approved Software Rating Tool.

Miscellaneous Energy Loads (MELs) – 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 and gas range/ovens.

National Appliance Energy Conservation Act (NAECA) – Legislation by the United States Congress that regulates energy consumption of specific household appliances in the United States, first passed as the Energy policy and Conservation Act in 1975 (Public Law 94-163) and amended in 1987 and 1988 (Public Laws 100-12 and 100-357), 1992 (Public Law 102-486) and 2005 (Public Law 109-58) and 2007 (Public Law 110-140).

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.

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 used to produce the on-site power, converted to equivalent electric energy use at a 40% conversion efficiency in accordance with Equation 4.1-3.

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

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

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

Qualifying Light Fixture – A light fixture located in a Qualifying Light Fixture Location that contains lamps (i.e. light bulbs) with an average luminous efficacy equal to or greater than 50 lumens/watt or a light fixture that is controlled by a photocell (outdoor fixtures) or by a motion sensor (indoor fixtures).

Qualifying Light Fixture Locations – For the purposes of rating, those light fixtures located in 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. This excludes plug-in lamps, closets, unfinished basements, and landscape lighting.

Renewable Energy System – Means of producing thermal energy or producing electric power that rely on naturally-occurring, on-site resources that are not depleted as a result of their use. Renewable Energy Systems shall include, but are not limited to, solar energy systems, wind energy systems and biomass energy systems.

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.

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 – The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area ($h \cdot ft^2 \cdot {}^oF/Btu$) [$m^2 \cdot K/W$].

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.

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.

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.[4]

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

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 Effective Leakage Area (ELA) of a home enclosure as defined by ASHRAE Standard 62.2-2013 divided by the home's Conditioned Floor Area, given in the same units of measure.

Threshold Specifications - A set of qualification criteria which are established based on a Worst-Case Analysis with consideration of all options or a set of prescriptive specifications such as the ENERGY STAR® prescriptive path adopted by the U.S. Environmental Protection Agency.

[4] (Informative Note) 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.

Therm – 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 – The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films ($Btu/h \cdot ft^{2} \cdot {}^{o}F$) [$W/m^{2} \cdot K$].

Unconditioned Space [5] **–**An area or room within a building that is not Conditioned Space but which may contain heat sources or sinks that influence the temperature of the area or room.

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 of indoor air to the outdoors for the purpose of drawing outdoor air into a home through open windows and doors for the purpose of cooling the home.

Whole-House Mechanical Ventilation System – An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air with outdoor air when operating continuously or through a programmed intermittent schedule to satisfy a whole house ventilation rate.

Window Film – Fenestration attachment products which consist of a flexible adhesive-backed polymer film which may be applied to the interior or exterior surface of an existing glazing system.

Worst-Case Analysis – An analysis 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 Analysis.

3.3. Acronyms.

AFUE – Annual Fuel Utilization Efficiency

ASHP – Air Source Heat Pump

[5] (Informative Note) Unconditioned Space represents the *simulation control volume* that is not mechanically controlled to specified conditions but whose conditions depend solely on the Unconditioned Space boundary conditions and its heat sources and sinks and on which an energy balance is performed by the simulation software.

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

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

Btu – British thermal unit

COP – Coefficient of Performance

CRRC – Cool Roof Rating Council

DAPIA – Design Approval Primary Inspection Agency

DOE – U.S. Department of Energy

DSE – Distribution System Efficiency

ELA – Effective Leakage Area

Eae – Electric Auxiliary Energy

EER – Energy Efficiency Ratio

EF – Energy Factor

EPA – U.S. Environmental Protection Agency

EPAct 92 – Energy Policy Act of 1992

GSHP – Ground Source Heat Pump

HERS® – Home Energy Rating System.[6]

HSPF – Heating Seasonal Performance Factor

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

HVAC – Heating, Ventilating and Air Conditioning

IDR – Innovative Design Request

IECC – International Energy Conservation Code

IRC – International Residential Code for One- and Two-Family Dwellings

IPIA – In-Plant Inspection Agency

IRS – U.S. Internal Revenue Service

kWh – kilowatt-hour

MELs – Miscellaneous Energy Loads

[6] (Informative Note) HERS® is a registered U.S. Trademark of Residential Energy Services Network, Inc.

MEPR – Manufacturer's Equipment Performance Rating

NAECA – National Appliance Energy Conservation Act

NREL – National Renewable Energy Laboratory

RESNET – Residential Energy Services Network, Inc.

SEER – Seasonal Energy Efficiency Ratio

SLA – Specific Leakage Area

4. Home Energy Rating Calculation Procedures.

4.1. Determining the HERS Index. The HERS Index for a residential building shall be determined in accordance with Sections 4.1.1 and 4.1.2.

4.1.1. Calculating End Use Loads. The normalized Modified End Use Loads (nMEUL) for space heating and cooling and domestic hot water use shall each be determined in accordance with 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 an Approved Software Rating Tool.

REUL = Reference Home End Use Loads (for heating, cooling or hot water) as computed using an Approved Software Rating Tool.

nEC_x = normalized Energy Consumption for the Rated Home's end uses (for heating, including Auxiliary Electric Consumption, cooling or hot water) as computed using an Approved Software Rating Tool.

EC_r = estimated Energy Consumption for the Reference Home's end uses (for heating, including Auxiliary Electric Consumption, cooling or hot water) as computed using an Approved Software Rating Tool.

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 an Approved Software Rating Tool.

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
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. The HERS Index shall be determined in accordance with Equation 4.1-2:

$$\text{HERS Index} = \text{PEfrac} * (\text{TnML} / \text{TRL}) * 100 \qquad \text{(Eq 4.1-2)}$$

where:

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

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

and where:

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

$REUL_{LA}$ = The Reference Home end use loads for lighting, appliances and MELs as defined by Section 4.2.2.5.1, converted to MBtu/y, where MBtu/y = (kWh/y)/293 or (therms/y)/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 (Btu_{fossil}) are converted to equivalent electric energy use (kWh_{eq}) in accordance with Equation 4.1-3.

OPP = On-Site Power Production as defined by Section 5.1.1.4 of this Standard.

$$kWh_{eq} = (Btu_{fossil} * 0.40) / 3412 \quad \text{(Eq 4.1-3)}$$

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 Gross area: same as Rated Home U-Factor: from Table 4.2.2(2) Solar absorptance = 0.75 Emittance = 0.90	Same as Rated Home Same as Rated Home Same as Rated Home Same as Rated Home 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 or outdoor environment:	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 Standards C-1549, E-1918, or CRRC Method # 1. Emittance values provided by the roofing manufacturer in accordance with ASTM Standard C-1371 shall be used when available. In cases

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

Building Component	HERS Reference Home	Rated Home
		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 or outdoor environment.	Same as the Rated Home, but not less net free ventilation area than the Reference Home unless an approved ground cover in accordance with 2012 IRC 408.3.1 is used, in which case, the same net free ventilation area as the Rated Home down to a 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 Orientation: North U-factor: same as fenestration from Table 4.2.2(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Glazing: [(a)]	Total area [(b)] =18% of CFA Orientation: equally distributed to four (4) cardinal compass orientations (N,E,S,&W) U-factor: from Table 4.2.2(2) SHGC: from Table 4.2.2(2) Interior shade coefficient: Summer = 0.70 Winter = 0.85 External shading: none	Same as Rated Home Same as Rated Home Same as Rated Home Same as Rated Home Same as HERS Reference Home [(c)] 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 and with energy loads	Tested in accordance with Section 802 of the *Mortgage Industry National*

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

Building Component	HERS Reference Home	Rated Home
	calculated in quadrature [f], [g]	*Home energy Rating Systems Standards* For residences , without Whole-House Mechanical Ventilation Systems, the measured infiltration rate [e] but not less than 0.30 ach For residences with Whole-House Mechanical Ventilation Systems, the measured infiltration rate [e] combined with the time-averaged Whole-House Mechanical Ventilation System rate,[f] which shall not be less than 0.03 x CFA + 7.5 x (Nbr+1) cfm and with energy loads calculated in quadrature [g]
Whole-House Mechanical ventilation:	None, except where a mechanical ventilation system is specified by the Rated Home, in which case: Where Rated Home has supply-only or exhaust-only Whole-House Ventilation System: 0.35*fanCFM*8.76 kWh/y Where Rated Home has balanced Whole-House Ventilation System without energy recovery: 0.70* fanCFM*8.76 kWh/y Where Rated Home has balanced Whole-House Ventilation System with energy recovery: 1.00*fanCFM*8.76 kWh/y And where fanCFM is calculated in accordance with Section 4.1.2 ASHRAE Standard 62.2-2013 for a continuous Whole-House Ventilation System.	Same as Rated Home
Internal gains:	As specified by Table 4.2.2(3)	Same as HERS Reference Home, except as provided by Section 4.2.2.5.2

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

Building Component	HERS Reference Home	Rated Home
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 [(h)] 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 Rated Home
	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	Same as Rated Home
	For other walls, for ceilings, floors, and interior walls, wood frame construction	Same as Rated Home
Heating systems [(i), (k)]	Fuel type: same as Rated Home	Same as Rated Home [(k)]
	Efficiencies:	
	Electric: air source heat pump in accordance with Table 4.2.2(1a)	Same as Rated Home
	Non-electric furnaces: natural gas furnace in accordance with Table 4.2.2(1a)	Same as Rated Home
	Non-electric boilers: natural gas boiler in accordance with Table 4.2.2(1a)	Same as Rated Home
	Capacity: sized in accordance with Section 4.3.3.1.	Same as Rated Home
Cooling systems [(i), (m)]	Fuel type: Electric	Same as Rated Home [(m)]
	Efficiency: in accordance with Table 4.2.2(1a)	Same as Rated Home
	Capacity: sized in accordance with Section 4.3.3.1.	Same as Rated Home
Service water heating systems [(i), (n), (p)]	Fuel type: same as Rated Home	Same as Rated Home [(n)]
	Efficiency	
	Electric: EF = 0.97 - (0.00132 * store gal)	Same as Rated Home
	Fossil fuel: EF = 0.67 - (0.0019 * store gal)	Same as Rated Home
	Use (gal/day): $30*N_{du} + 10*N_{br}$ where N_{du} = number of	Same as HERS Reference Home

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

Building Component	HERS Reference Home	Rated Home
	dwelling units Tank temperature: 120 F	Same as HERS Reference Home
Thermal distribution systems:	Thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies.	For forced air distribution systems: Tested in accordance with Section 803 of the *Mortgage Industry National Home Energy Rating Systems Standards* [(o)], and then either calculated through hourly simulation or calculated in accordance with ASHRAE Standard 152-2004 with the ducts located and insulated as in the Rated Home. For ductless distribution systems: DSE=1.00 For hydronic distribution systems: DSE=1.00
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 4.3.1

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 of 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 one- and two-family dwellings with conditioned basements and dwelling units in residential buildings not over three stories in height above grade containing multiple dwelling units the following formula shall be used to determine total window area:

AG = 0.18 x CFA x FA x F

where:
AG = Total glazing area
CFA = Total Conditioned Floor Area

FA = (gross above-grade thermal boundary wall area) / (gross above-grade thermal boundary wall area + 0.5*gross below-grade thermal boundary wall area)

F = 1- 0.44* (gross common wall Area) / (gross above-grade thermal boundary wall area + gross common wall area)

and where:

Thermal boundary wall is any wall that separates Conditioned Space from Unconditioned Space, outdoor environment or the surrounding soil.

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

Below-grade thermal 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 true 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 Effective Leakage Area (ELA) is defined in accordance with Equation 4.4 of ASHRAE Standard 62.2-2013, and where SLA = ELA / CFA (where ELA and CFA are in the same units).

(e) Tested envelope leakage shall be determined and documented using the on-site inspection protocol as specified in Section 802 of the *Mortgage Industry National Home Energy Rating Systems Standards* by an Approved Tester.

(f) The combined air exchange rate for Infiltration and Whole-House Mechanical Ventilation Systems shall be determined in accordance with Equation 4.6 of ASHRAE Standard 62.2-2013.

(g) Either hourly calculations using the procedures given in the 2013 ASHRAE Handbook of Fundamentals (IP version), Chapter 16, page 16.25, Equation 51 using Shelter Class 4 or calculations yielding equivalent results shall be used to determine the energy loads resulting from infiltration in combination with Whole-House Mechanical Ventilation systems.

(h) 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 true south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

(i) 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 minimum efficiencies given in Table 4.2.2(1a) below will be assumed for:

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

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

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

Table 4.2.2(1a). HERS Reference Home
Heating and Cooling Equipment Efficiencies

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 [(a)]	Heating	63% Efficiency

Notes:
(a) Biomass fuel systems shall be included in ratings only when a permanent heating system sized to meet the load of the dwelling unit does not exist. Where installed to supplement a permanent heating system that cannot meet the load of the dwelling unit, the biomass system shall be assigned only that part of the load that cannot be met by the permanent heating system.

(k) For a Rated Home without a heating system, a gas heating system with the efficiency provided in Table 4.2.2(1a) shall be assumed for both the HERS Reference Home and Rated Home. For a Rated home that has no access to natural gas or fossil fuel delivery, an air-source heat pump with the efficiency provided in Table 4.2.2(1a) shall be assumed for both the HERS Reference Home and Rated Home.

(m) For a Rated Home without a cooling system, an electric air conditioner with the efficiency provided in Table 4.2.2(1a) shall be assumed for both the HERS Reference Home and the Rated Home.

(n) For a Rated Home with a non-storage type water heater, a 40-gallon storage-type water heater of the same fuel as the proposed water heater shall be assumed for the HERS Reference Home. For tankless water heaters, the Energy Factor (EF) shall be multiplied by 0.92 for Rated Home calculations. For a Rated Home without a proposed water heater, a 40-gallon storage-type water heater of the same fuel as the predominant fuel type used for the heating system(s) shall be assumed for both the Rated and HERS Reference Homes. In both cases the Energy Factor of the water heater shall be as prescribed for water heaters by CFR 430.32(d), published in the Federal Register/Volume 66, No. 11, Wednesday, January 17, 2001 for water heaters manufactured after January 20, 2004.

(o) Tested duct leakage shall be determined and documented by an Approved Tester using the protocols specified in Section 803 of the *Mortgage Industry National Home Energy Rating Systems Standards*.

(p) Raters shall obtain Energy Factors (EF) for domestic hot water equipment from manufacturer's literature or from AHRI directory for equipment being used, where available. For instances where a manufacturer provided or AHRI published EF is not available (e.g. commercial water heaters), the rater shall use the guidance provided here to determine the effective EF of the water heater.

i. For residential oil, gas and electric water heaters or heat pumps, default EF values provided in Table 4.4.2(3) for age-based efficiency or Table 4.4.2(4) for non-age-based efficiency shall be used.

ii. For commercial water heaters used in residential applications, one of the following approaches shall be followed to determine the EF for a particular piece of equipment.

   a. Use an approved commercial hot water system calculator
   b. Use Table C404.2 Minimum Performance of Water Heating Equipment in the 2012 IECC to find the minimum requirement for the type of water heater.

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

Climate Zone [(b)]	**Fenestration and Opaque Door U-Factor**	**Glazed Fene-stration Assembly SHGC**	**Ceiling U-Factor**	**Frame Wall U-Factor**	**Floor Over Uncond-itioned Space U-Factor**	**Basement Wall U-Factor** [(c)]	**Slab-on-Grade R-Value & Depth** [(d,e)]
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	0.40	0.030	0.082	0.047	0.059	10, 2 ft.
5 and Marine 4	0.35	0.40	0.030	0.060	0.033	0.059	10, 2 ft.
6	0.35	0.40	0.026	0.060	0.033	0.059	10, 4 ft.
7 and 8	0.35	0.40	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 2006 IECC.
(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
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:
(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 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 element framing fractions shall be in accordance with 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%

Table 4.2.2(6) Default Framing Fractions for Enclosure Elements

Enclosure Element	Frame Spacing (in o.c.)	Default Frame Fraction (% area)
Structural Insulated Panels	48	10%
Floors (standard):		
@16" o.c.	16	13%
@24" o.c.	24	10%
Floors (advanced):		
@16" o.c.	16	11%
@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 such as or equivalent to Appendix A of the *Mortgage Industry National Home Energy Rating Systems Standard*.

4.2.2.2.1. The insulation of the HERS Reference Home enclosure elements shall be modeled as Grade I. The insulation of the Rated Home shall either be inspected according to procedures such as or equivalent to Appendix A of the *Mortgage Industry National Home Energy Rating Systems Standards* or, if not inspected, shall be modeled as Grade III and shall be recorded as "not inspected" in the rating.

Exceptions:

(a) Modular and manufactured housing using IPIA inspections shall be considered as an acceptable alternative for the HERS inspection where the manufacturer of the home includes the on-site inspection procedures for insulation details and requirements in their DAPIA packages, which are used by IPIA's for their factory inspections.

(b) The R-values for non-structural materials or for Structural Insulated Panels (SIP's), Insulated Concrete Forms (ICF's), and other pre-manufactured assemblies when accompanied by supporting test data consistent with ASTM C 177-10, ASTM C 518-10, ASTM C 1114-06, ASTM C236-93 or ASTM C 976-96.

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:

(a) 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 batt, loose fill, sprayed insulation or insulated siding) 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.

(b) 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.

(c) Areas of an assembly having different insulation types or R-values (including uninsulated areas in excess of 5% of any otherwise insulated building component) shall be modeled separately, with the applicable R-values and assembly areas associated with each different insulation situation.

(d) The overall thermal properties of steel-framed walls, ceilings and floors shall be calculated in accordance with the modified zone method specified by Chapter 27, 2013 ASHRAE Handbook of Fundamentals or tested in accordance with ASTM Standard C-1363-11. Test results may be modified to add or subtract R-values to the tested assembly that reflect differences between the tested assembly and proposed assemblies when such differences are continuous and occur outside of the cavity.

4.2.2.3. Renewable Energy Systems that 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) and Table 4.2.2.5(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 Table 4.2.2.5(1).

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

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

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 for HERS Reference Homes with gas appliances

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

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/y shall be added to the energy use of the Reference Home to account for garage lighting.

4.2.2.5.1.4. 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.

4.2.2.5.2. HERS Rated Homes. The lighting, appliance and miscellaneous electric loads in the HERS Rated Home shall be determined in accordance with Sections 4.2.2.5.2.1 through 4.2.2.5.2.12.

4.2.2.5.2.1. Residual MELs. Residual miscellaneous annual electric energy use in the Rated Home shall be the same as in the HERS Reference Home and shall be calculated as 0.91*CFA.

4.2.2.5.2.2. Interior Lighting. Interior lighting annual energy use in the Rated home shall be determined in accordance with Equation 4.2-2:

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

where:

CFA = Conditioned Floor Area

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

For rating purposes, the Rated Home shall not have qFF_{IL} less than 0.10 (10%).[7]

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/y, where MBtu/y = (kWh/y)/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 annual energy use in the Rated home shall be determined in accordance with Equation 4.2-3:

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

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/y, where MBtu/y = (kWh/y)/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 annual lighting energy use in the Rated home shall be determined in accordance with Equation 4.2-4:

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

where:

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

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

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

Reference Home in Section 4.2.2.5.1 (i.e. 100 kWh/y), converted to MBtu/y, where MBtu/y = (kWh/y)/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 annual energy use for the Rated Home shall be determined from either refrigerator Energy Guide labels or from age-based defaults in accordance with 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-Present	0.77

Default values for adjusted volume (AV) shall be determined in accordance with Table 4.2.2.5.2.5(3)

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

Model Type	Default Equation
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/y, where MBtu/y = (kWh/y)/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 Space or outdoor environment (e.g. an unconditioned garage)

4.2.2.5.2.6. Televisions. Television annual 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/y = 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) annual energy use for the Rated Home shall be determined in accordance with Equations 4.2-5a through 4.2-5c, as appropriate.

1) For electric cooking:
kWh/y = BEF * OEF * (331 + 39*Nbr) **(Eq 4.2-5a)**

2) For natural gas cooking:
Therms/y = OEF*(22.6 + 2.7*Nbr) **(Eq 4.2-5b)**
plus:
kWh/y = 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/y, where MBtu/y = (kWh/y) / 293 or (therms/y) / 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 annual energy use for the Rated Home shall be determined in accordance with Equation 4.2-6.

kWh/y = 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 [8] or the default value of 3.01.

CAPw = Capacity of clothes washer (ft^3) from the manufacturer's data **or** the CEC database **or** the EPA Energy Star website [9] **or** the default value of 2.874 ft^3.

MEF[10] = Modified Energy Factor of clothes washer from the Energy Guide label **or** the default value of 0.817.

LER = Labeled Energy Rating of clothes washer (kWh/y) from the Energy Guide label **or** the default value of 704.

For natural gas clothes dryers, annual energy use shall be determined in accordance with Equations 4.2-7a and 4.2-7b.

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

kWh/y = (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** the default value of 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 this section minus the annual clothes dryer energy use derived for the HERS

[8] (Informative Reference) http://www.appliances.energy.ca.gov/

[9] (Informative Reference) http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

[10] (Informative Note) 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.

Reference Home in Section 4.2.2.5.1, converted to MBtu/y, where MBtu/y = (kWh/y) / 293 or (therms/y) / 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 Space or outdoor environment (e.g. an unconditioned garage)

4.2.2.5.2.9. Dishwashers. Dishwasher annual energy use for the Rated Home shall be determined in accordance with Equation 4.2-8a.

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

where:
EF = Labeled dishwasher energy factor
or
EF = 215/(labeled kWh/y)
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 in accordance with Equation 4.2-8b.

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 dishwasher energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/y, where MBtu/y = (kWh/y) / 293 or (therms/y) / 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.

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 in accordance with Equation 4.2-9a.

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/y) from the 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[11] **or** the EPA Energy Star website [12] **or** the default value of 2.874 ft^3

Daily hot water use shall be calculated in accordance with Equation 4.2-9b.

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/y, where MBtu/y = (kWh/y) / 293 **or** (therms/y) / 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

[11] (Informative Reference) http://www.appliances.energy.ca.gov/

[12] (Informative Reference) http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

modified for clothes washers located in Unconditioned Space or outdoor environment (e.g. an unconditioned garage)[13]

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 months with an average outdoor 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 these months.

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 in accordance with Equation 4.2-10.

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/y [(kWh/y)/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 4.1-2 in Section 4.1.2.

4.2.2.5.2.12. Whole-House Mechanical Ventilation System Fans. If Whole-House Mechanical Ventilation System 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/y, where MBtu/y = (kWh/y) / 293.

4.2.2.6. If the Rated Home includes On-site Power Production, the Purchased Energy Fraction for the Rated Home as specified by Equation 4.1-2 in Section 4.1.2 shall be used to determine the impact of the On-site Power Production on the HERS Index.

[13] (Informative Note) 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: http://www.appliances.energy.ca.gov/

4.3. Operating Condition Assumptions. The annual purchased energy consumption for heating, cooling and hot water for both the Rated Home and the Reference Home shall be estimated in accordance with sections 4.3.1 through 4.3.7.

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 TMY3 or equivalent climate data.

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 capacity shall be selected in accordance with ACCA Manual S based on building heating and cooling loads calculated in accordance with Manual J, Eighth Edition, ASHRAE 2013 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 * wsf

(b) For winter: 1.6 * nL * wsf

where:

nL = 0.48

wsf = Weather and shielding factor from Tables in ASHRAE Standard 62.2-2013.

4.3.3.1.4. Whole-House Mechanical Ventilation rate 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/h sensible for appliances plus 230 Btu/h sensible and 200 Btu/h latent per occupant, with the number of occupants equal to the number of Bedrooms plus one.

4.3.3.1.7. Heat pump equipment capacity shall be sized to equal the larger of the building heating and cooling loads calculated in accordance with these procedures.

4.3.3.1.8. Systems shall not be larger 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 * wsf
(b) For winter: either 1.6 * ach,nat or 1.6 * nL * wsf
where:
nL = 0.48
wsf = Weather and shielding factor from Tables in ASHRAE Standard 62.2-2013.

4.3.3.2.4. Where a Whole-House Mechanical Ventilation System(s) is provided, the Whole-House Mechanical Ventilation flow rate shall be included. Flow rates for bathroom, kitchen and other local exhaust that does not serve as a component of a Whole-House Mechanical Ventilation System shall not be considered for sizing purposes.

4.3.3.2.5. Combined infiltration and ventilation may not be less than the ventilation rates required by ASHRAE Standard 62.2-2013, nor greater than nL * wsf * 1.2 in summer and nL * wsf * 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/h sensible plus 230 Btu/h sensible and 200 Btu/h latent per occupant, with the number of occupants equal to the number of Bedrooms plus one.

4.3.3.2.8. Heat pump equipment capacity shall be sized to equal the larger of the building heating and cooling loads calculated in accordance with these procedures.

4.3.3.2.9. To the degree that the installed equipment capacity for the Rated Home exceeds properly sized equipment in accordance with the above procedures, the impact of the over-sizing on part-load performance shall be accounted 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 residential ground-loop and ground-water water-to-air heat pumps that are shipped with an integral blower fan and without a fluid circulation pump, the Auxiliary Electric Power shall be determined as follows:

GSHP Auxiliary Electric Consumption (kWh/y) = $GSHP_{pump}$ - $GSHP_{intp}$ + $GSHP_{fanESP}$

where:

$GSHP_{pump}$ in watts is the observed pump nameplate data (Volts *Amps) shall be added for all periods 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.

$GSHP_{intp}$ in watts is the estimated pump power required to overcome the internal resistance of the ground-water heat exchanger under AHRI test conditions. $GSHP_{intp}$ = W/ton * rated cooling Btu/h/12,000. W/ton shall be 30 for ground loop (closed loop) systems and 15 for ground water (open loop) heat pump systems.

$GSHP_{fan}$: If ducts are attached to the system to deliver heating or cooling, the external fan energy in watts, $GSHP_{fan}$ = (air flow in CFM * 0.2 watts per CFM), shall be added for all periods of heat pump operation. The air flow in CFM shall be (400 * rated cooling Btu/h / 12,000), where 400 is the air flow in CFM per ton (12 kBtu/h) of capacity. Note that for the purposes of calculating adjusted equipment efficiency, $GSHP_{fanESP}$ shall also be added to the rated heating capacity, and subtracted from the rated cooling capacity of the equipment. For that adjustment, $GSHP_{fanESP}$ shall be converted to Btu/h by Btu/h = $GSHP_{fanESP}$ * 3.412.

For the purpose of projected ratings only, if $GSHP_{pump}$ cannot be determined, the following adjustments may be made to the rated efficiency of the GSHP:

Adjusted EER (closed loop) = 0.0000315*EER^3 - 0.0111*EER^2 + 0.959*EER
Adjusted COP (closed loop) = 0.000416*COP^3 - 0.041*COP^2 + 1.0086*COP
Adjusted EER (open loop) = 0.00005*EER^3 - 0.0145*EER^2 +0.93*EER
Adjusted COP (open loop) = 0.00067*COP^# - 0.0531*COP^2 + 0.976*COP

4.3.6. Fossil Fuel Fired Furnaces and Boilers. For a fossil fuel fired furnace or boiler, the Auxiliary Electric Consumption shall be determined as follows:

Auxiliary Electric Consumption (kWh/y) = Eae * (HLH) / 2080)

where:

HLH = annual heating load hours seen by the furnace/boiler.
Note: If fan power is needed (kW), it is determined by Eae / 2080.

4.3.7. 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.

4.3.8. 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. The estimated annual purchased energy consumption for heating, cooling, water heating and lighting and appliances set forth in Section 4.2 shall be determined 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 4.4.2 cannot be obtained by observation or without destructive disassembly of the home, default values shall be used based on current and historical local building practice and building codes and for modular or manufactured housing available data from the manufacturer.

4.4.2. Standard Features. The minimum rated features associated with the home shall be determined in accordance with Sections 4.4.2.1 through 4.4.2.4.

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

4.4.2.2. The air leakage and duct leakage values set forth as building elements 10 and 11 in Table 4.4.2(1) shall be determined by using current on-site diagnostic tests conducted in accordance with the requirements set forth in Table 4.2.2(1).

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) shall be 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; or,

(b) Name plate data; or,
(c) Manufacturer's data sheet; or,
(d) Equipment directories; or,
(e) When information on the energy efficiency of mechanical equipment cannot be determined, the values set forth in Tables 4.4.2(2); 4.4.2(3); 4.4.2(4) and 4.4.2(5).

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 Assembly	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 (of complete assembly), shading.
7. Skylights	Construction type, orientation, tilt, U-value (of complete assembly), solar heat gain coefficient (of complete assembly), shading.
8. Passive Solar System (Direct Gain system)	Solar type, collector type and area, orientation, tilt efficiency, storage tank size, and 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.

Table 4.4.2(1) Minimum Rated Features

Building element	Minimum Rated Feature
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 Energy (Eae); power rating 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)).
17. Refrigerator(s)	Total annual energy consumption (kWh) for all units as determined from either the refrigerator Energy Guide label or from age-based defaults as defined in Section 4.2.2.5.2.5.
18. Dishwasher(s)	Labeled energy factor (cycles/kWh) or labeled energy consumption (kWh/y) for all units as defined in Section 4.2.2.5.2.9.
19. Range/Oven	Burner Energy Factor (BEF) and Oven Energy Factor (OEF) as defined in Section 4.2.2.5.2.7.
20. Clothes Washer	Energy Rating (kWh/y), electric rate ($/kWh), annual gas cost (AGC), and gas rate ($/therm) from Energy Guide label; and washer capacity (cubic feet) from manufacturer's data or the CEC database or the EPA ENERGY STAR website as defined in Section 4.2.2.5.2.10.
21. Clothes Dryer	Clothes washer Modified Energy Factor (MEF) and clothes washer Labeled Energy Rating (kWh/y) from Energy Guide label; clothes washer capacity from manufacturer's data or CEC database or EPA ENERGY STAR website; and clothes dryer Efficiency Factor from CEC database as defined in Section 4.2.2.5.2.8.
22. Ceiling Fans	Labeled cfm, Watts and cfm/Watt at medium fan speed from EPA ENERGY STAR ceiling fan label.
23. Whole-House Mechanical Ventilation System(s)	Equipment type, daily run hours, and wattage (may be listed in the Certified Home Ventilating Products Directory available from the Heating and Ventilation Institute (HVI).
24. On-site Power Production	Total annual kWh generation and total site fuel used in the On-Site Power Production 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/caa/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 Listed	Unconditioned space	50%	For stoves with 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

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

Type	Location	Seasonal Efficiency	Notes
			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) [(a)]

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
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

Table 4.4.2(3) Default Values for Mechanical System Efficiency (Age-based) [(a)]

Mechanical Systems	Units	Pre-1960	1960-1969	1970-1974	1975-1983	1984-1987	1988-1991	1992--2005	2006-present
(a) 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) [(a)]

Mechanical Systems	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
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
(a) 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)

4.5. 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 existing appliance (e.g., refrigerator) is replaced with a new appliance as part of the improvement, but the existing appliance is not removed from the property, both the new and existing appliance shall be included in the Improved Home model.

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). The configuration of the Baseline Home shall not violate the specified input constraints in Table 4.5.3(1).

Table 4.5.3(1) Baseline Existing Home Input Constraints

Equipment Constraints [(a)]	**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
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
(a) 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 CFA 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 CFA 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 CFA 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.

4.5.4. Energy Savings Calculation

4.5.4.1. Energy units used in the calculation of energy savings shall be the total whole-house energy use of all fuels (kWh_{tot}) calculated in accordance with Equation 4.5-1.

$$\mathbf{kWh_{tot} = kWh_{elec} + kWh_{eq}} \qquad \textbf{(Eq 4.5-1)}$$

where

kWh_{tot} = total whole-house energy use of all fuels used by the home

kWh_{elec} = whole-house electric energy used by the home

kWh_{eq} = whole-house fossil fuel energy used by the home converted to equivalent electric energy use in accordance with Equation 4.1-3

4.5.4.2. Whole-house energy savings (kWh_{tot}) shall be calculated as the difference between the total whole-house energy use (kWh_{tot}) of the Baseline Existing Home and the total whole-house energy use (kWh_{tot}) of the Improved Home.

4.5.4.3. The energy savings percentage of the retrofit shall be calculated as the whole-house total energy savings (kWh_{tot}) as determined by Section 4.5.4.2 divided by the whole-house total energy use (kWh_{tot}) 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 in accordance with Equations 4.6-1 and 4.6-2.

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

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

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 1st 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 Equations 4.6-6a through 4.6-8d.[14]:

$$\mathbf{P1 = 1/(DR-ER)*(1-((1+ER)/(1+DR))\text{\^{}}nAP)} \quad \textbf{(Eq 4.6-6a)}$$

or if DR = ER then

$$\mathbf{P1 = nAP / (1+DR)} \quad \textbf{(Eq 4.6-6b)}$$

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

$$\mathbf{P2 = DnPmt + P2_A + P2_B + P2_C - P2_D} \quad \textbf{(Eq 4.6-7)}$$

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

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

$P2_C$ = 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[15]
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. Standard Economic Inputs. The economic parameter values used in the cost effectiveness calculations specified in Section 4.6.1 shall be determined in accordance with Sections 4.6.2.1 through 4.6.2.10. [16]

[15] (Informative Note) 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 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.

[16] (Informative Note) RESNET shall annually publish Standard Economic Input values for the General Inflation Rate (GI), Discount Rate (DR), Mortgage Interest Rate (MR), Down Payment Rate (DnPmt) and

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,[17] where ACR shall be calculated in accordance with Equation 4.6-9:

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

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[18] 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.

Energy Inflation Rate (ER) determined in accordance with this Section that can be used by Approved economic calculation tools.

[17] (Informative Reference) http://www.bls.gov/CPI/#tables

[18] (Informative Reference) Table 3A from detailed reports listed at http://www.bls.gov/cpi/cpi_dr.htm

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

4.6.2.8. Remaining Life Fraction (RLFrac) shall be calculated in accordance with Equation 4.6-10.

$$\textbf{RLFrac} = (\textbf{nAP/Life}) - (\textbf{Integer (nAP/Life)}) \qquad \textbf{(Eq 4.6-10)}$$

or if Life > nAP

$$\textbf{RLFrac} = (\textbf{Life-nAP}) / \textbf{nAP}$$

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 associated with the minimum provisions of the energy code or standard in effect where the building is located 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.

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. Certification and Labeling. This section establishes minimum uniform standards for certifying and labeling home energy performance using the HERS Index. These include minimum requirements of the Home Energy Rating process, standard methods for estimating energy use, energy cost and pollution emission savings, minimum reporting requirements, and specification of the types of ratings that may be performed in accordance with this Standard.

5.1. Rating Requirements.

5.1.1. General. The rating for a home shall be determined in accordance with sections 5.1.1.1 through 5.1.1.5.

5.1.1.1. For an existing home, required data shall be collected on site.

5.1.1.2. For a new, to-be-built home, the procedures of Section 4.4 shall be used to collect required data.

5.1.1.3. The collected data shall be used 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 specified by Section 4.2

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 energy use of any purchased fossil fuels used to produce the electric power in accordance with Equation 4.1-3.[19] The HERS Reference Home shall not include On-site Power Production.

5.1.1.5. Estimates completed using Sections 5.1.1.3 and 5.1.1.4 shall comply with Sections 5.1.1.5.1 through 5.1.1.5.3.

5.1.1.5.1. All estimates shall assume the standard operating conditions of Section 4.3.

5.1.1.5.2. All estimates shall be based on the minimum rated features of Section 4.4.

5.1.1.5.3. All estimates shall be calculated using an Approved Software Rating Tool.

5.1.2. Savings Estimates.

5.1.2.1. Energy Cost Savings. Where determined, the energy cost savings for the Rated Home shall be calculated in accordance with Sections 5.1.2.1.1 and 5.1.2.1.2.

5.1.2.1.1. Energy Prices. Energy costs for all homes shall be calculated using state-wide, revenue-based energy price rate data published annually by the U.S. Department of Energy (DOE), Energy Information Administration (EIA).[20]

5.1.2.1.2. Energy Cost Savings. Energy cost saving estimates of the Rated Home for Confirmed, Sampled, and Projected Ratings shall be calculated in accordance with Sections 5.1.2.1.2.1 through 5.1.2.1.2.4.

5.1.2.1.2.1. HERS Reference Home energy costs shall be determined by fuel type, applying the energy price rates 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, applying the same energy price rates used for the HERS Reference Home.

5.1.2.1.2.3. Estimated energy cost savings with respect to the HERS Reference Home shall be the difference between the estimated energy costs for the HERS Reference Home and the estimated energy costs for the Rated Home.

[19] (informative Note) 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 = 3.412 MBtu - (6 MBtu * 0.4) = 1.0 MBtu. On the other hand, if 1000 kWh was produced by a low efficiency fossil fuel system using 17 MBtu of fuel, then OOP = 3.412 - (17 * 0.4) = -3.387 MBtu.

[20] (Informative Note) RESNET will compile and publish state-wide, revenue-based electricity price data that can be used in accordance with this section by Approved Software Rating Tools for the calculation of electricity costs.

5.1.2.1.2.4. Estimated energy cost savings with respect to the Typical Existing Home shall be determined in accordance with Sections 5.1.2.1.2.4.1 and 5.1.2.1.2.4.2.

5.1.2.1.2.4.1. For each fuel type, the HERS Reference Home costs shall be multiplied by 1.3 to determine the Typical Existing Home estimated energy costs by fuel type.

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

5.1.2.2. Pollution Emission Savings. Where determined, the pollution emission savings for the Rated Home shall be calculated in accordance with Sections 5.1.2.2.1 and 5.1.2.2.2.

5.1.2.2.1. Pollution Emissions. Pollution emissions for all homes shall be calculated in accordance with Sections 5.1.2.2.1.1 and 5.1.2.2.1.2.

5.1.2.2.1.1. For electricity use, data for the sub-region annual total output emission rates published by Environmental Protection Agency's 2012 eGrid database[21] for electricity generation shall be used to calculate emissions.[22]

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).

Table 5.1.2(1) National Average Emission Factors for Household Fuels[23]

Fuel Type	Units	MBtu per Unit	CO_2 lb/MBtu	NOx lb/MBtu	SO_2 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
Liquid Petroleum Gas (LPG)	Gallon	0.0915	136.4	153.4	0.0163

5.1.2.2.2. Pollution Emission Savings. Estimated pollution emission savings for the Rated Home shall be calculated in accordance with Sections 5.1.2.2.2.1 through 5.1.2.2.2.3.

[21] (Informative Reference) http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
[22] (Informative Note) RESNET will compile and publish annual total output pollution rate data for NOx, SO_2 and CO_2 in accordance with the provisions of this Section that can be used by Approved Software Rating Tools for the calculation of emissions.
[23] (Informative Note) 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

5.1.2.2.2.1. The 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. The 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 in accordance with Sections 5.1.2.2.2.3.1 and 5.1.2.2.2.3.2.

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 in accordance with Sections 5.1.2.2.2.3.2.1 and 5.1.2.2.2.3.2.2.

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

5.1.3. Reports. All reports generated by an Approved Software Rating Tool shall, at a minimum, contain the information specified by Sections 5.1.3.1 through 5.1.3.6.

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 Approved 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 Approved Software Rating Tool (including version number) used to determine the Rating.

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. There shall be three Rating Types in accordance with Sections 5.1.4.1 through 5.1.4.3.

5.1.4.1. Confirmed Rating. A Rating Type that encompasses one individual dwelling or dwelling unit and is conducted in accordance with Sections 5.1.4.1.1 through 5.1.4.1.3.

5.1.4.1.1. All Minimum Rated Features of the Rated Home shall be field-verified through inspection and testing in accordance with Section 4.4.

5.1.4.1.2. All field-verified Minimum Rated Features of the Rated Home shall be entered into the Approved Software Rating Tool that generates the Home Energy Rating. The Home Energy Rating shall report the HERS Index that comports with these inputs.

5.1.4.1.3. Confirmed Ratings shall be subjected to the Quality Assurance requirements such as or equivalent to Section 900 of the *Mortgage Industry National Home Energy Rating Systems Standard*.

5.1.4.2. Sampled Ratings. A Rating Type that encompasses a set of dwellings or dwelling units and is conducted in accordance with Sections 5.1.4.2.1 through 5.1.4.2.3.

5.1.4.2.1. For the set of Rated Homes, all Minimum Rated Features shall be field-verified through inspection and testing of a single home in the set, or distributed across multiple homes in the set, in accordance with requirements such as or equivalent to Section 600 of the *Mortgage Industry National Home Energy Rating Systems Standard*.

5.1.4.2.2. The threshold specifications from the Worst-Case Analysis for the Minimum Rated Features of the set of Rated Homes shall be entered into the Approved Software Rating Tool that generates the Home Energy Rating. The Home Energy Rating shall report the HERS Index that comports with these inputs.

5.1.4.2.3. Sampled Ratings shall be subjected to the Quality Assurance requirements such as or equivalent to Section 900 of the *Mortgage Industry National Home Energy Rating Systems Standard*.

5.1.4.3. Projected Ratings. A Rating Type that encompasses one individual dwelling or dwelling unit and is conducted in accordance with Sections 5.1.4.3.1 through 5.1.4.3.5.

5.1.4.3.1. All minimum Rated Features of the Rated Home shall be determined from architectural drawings, threshold specifications, and the planned location and orientation for a new home or from a site audit and threshold specifications for an existing home that is to be improved. For a new home, if the proposed orientation is unknown, the home shall be analyzed facing each of the four cardinal directions (i.e.,

North, South, East and West) and the orientation resulting in the largest HERS Index shall be used.

5.1.4.3.2. 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 the air exchange rate specified for the HERS Reference home in Table 4.2.2(1).

5.1.4.3.3. 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 the thermal distribution system efficiency value specified for the HERS Reference home in Table 4.2.2(1).

5.1.4.3.4. The Minimum Rated Features of Rated Homes that were determined in Section 5.1.4.3.1 through 5.1.4.3.3 shall be entered into the Approved Software Rating Tool that generates the Home Energy Rating. The Home Energy Rating shall report the HERS Index that comports with these inputs.

5.1.4.3.5. 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."

5.2. Innovative Design Requests.

5.2.1. Petition. HERS providers can petition RESNET[24] for adjustment to the HERS Index for a Rated Home with features or technologies not addressed by Approved Software Rating Tools and/or this Standard. Innovative Design Requests (IDRs) to RESNET shall include, at a minimum, the following:

5.2.1.1. A Rating generated from Approved Software Rating Tool for Rated Home without feature(s) that cannot be modeled in the software tool.

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

5.2.1.3. Manufacturer's technical and/or performance specifications for feature(s) not included in the Rating generated from the Approved Software Rating Tool.

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

[24] (Informative Note) Residential Energy Services Network, Inc., P.O. Box 4561, Oceanside, CA 92052-4561. http://www.resnet.us

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

5.2.2. Review. Upon review of an IDR, the RESNET Standards Development Committee 300 (SDC 300) shall either request additional supporting documentation for further consideration or provide a recommendation with justification to the Standards Management Board (SMB) as follows: a) recommend approval, b) recommend denial, or c) recommend approval with modifications.

5.2.3. Approval. IDRs shall be approved on a case by case basis. The SMB shall accept or reject the recommendation of SDC 300 or shall request further information from SDC 300. 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.

5.3. Labeling. Home energy rating labels shall, at a minimum, contain the information specified by Sections 5.3.1 through 5.3.6

5.3.1. Real property physical address of the home, including city and state or territory

5.3.2. HERS Index Score of the home

5.3.3. Projected annual site energy use of the home by fuel type

5.3.4. Projected annual energy cost of the home, calculated in accordance with energy price rate provisions of Section 5.1.2.1.2.

5.3.5. Name and address of the Approved Rating Provider

5.3.6. Date of the home energy rating.

6. Normative References.

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

AACA, “Manual S Residential Heating and Cooling Equipment Selection.” Air Conditioning Contractors of America, Arlington, VA.

ASHRAE *Handbook of Fundamentals*, 2013. American Society of Heating Refrigerating and Air Conditioning Engineers, Atlanta, GA.

ANSI/ASHRAE 62.2-2013, “Ventilation and Acceptable Indoor Air Quality in Low Rise Buildings.” American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA, 2013.

ANSI/ASHRAE 90.2-2007, “Energy Efficient Design of Low Rise Buildings.” American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA, 2012.

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ANSI Z765-2012, “Square Footage – Method for Calculating.” National Association of Home Builders Research Center, Upper Marlboro, MD.

ASTM C 177-10, “Standard Test Method for Stead-State Heat Flux Measurement and Thermal Transmission Properties by means of the Guarded-Hot-Plate Apparatus.” ASTM International, West Conshohocken, PA.

ASTM C 236-93, “Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box.” ASTM International, West Conshohocken, PA.

ASTM C 518-10, “Standard Test Method for Stead-State Thermal Transmission Properties by means of the Heat Flow Meter Apparatus.” ASTM International, West Conshohocken, PA.

ASTM C 976-96, ”Thermal Performance of Building Assemblies by Means of a Calibrated Box.” ASTM International, West Conshohocken, PA.

ASTM C1114-06, “Standard Test Method for Stead-State Thermal Transmission Properties by means of The Thin-Heater Apparatus.” ASTM International, West Conshohocken, PA.

ASTM C1363-11, “Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus.” ASTM International, West Conshohocken, PA.

ASTM C1371 - 04a(2010)e1, “Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers.” ASTM International, West Conshohocken, PA.

ASTM C1549-09, “Standard Test Method for Determining Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer,” ASTM International, West Conshohocken, PA.

ASTM E1918-06, “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.

EPA, eGrid2012, Version 1.0, U.S. Environmental Protection Agency, Washington, DC. Database (online at http://www.epa.gov/cleanenergy/energy-resources/egrid/)

ICC, 2012, “2012 International Residential Code.” International Code Council, 500 New Jersey Avenue, NW, Washington, DC.

RESNET, January 2013, *Mortgage Industry National Home Energy Rating Systems Standards.* Residential Energy Services Network, Oceanside CA.

United States Congress, *National Appliance Energy Conservation Act (NAECA).* First passed in 1975 (Public Law 100-12) and amended in 1987 (Public Law 100-357), 1992 (Public Law 102-486) and 2005 (Public Law 109-58).

7. Informative References.

Bureau of Labor Statistics, http://www.bls.gov/CPI/#tables

Bureau of Labor Statistics, Table 3A from detailed reports listed at http://www.bls.gov/cpi/cpi_dr.htm

Consortium for Energy Efficiency, http://www.cee1.org/resid/seha/dishw/dishw-main.php3

California Energy Commission, http://www.appliances.energy.ca.gov/

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

Environmental Protection Agency, http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

Environmental Protection Agency, http://www.epa.gov/compliance/resources/publications/monitoring/caa/woodstoves/certifiedwood.pdf

Residential Energy Services Network, Inc., P.O. Box 4561, Oceanside, CA 92052-4561 (http://www.resnet.us)

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.

ANSI/RESNET 301-2014 Addendum A-2015
Amendment on Domestic Hot Water (DHW) Systems

Add new definitions to Section 3.2

Approved Hot Water Operational Control Device – A means of controlling the waste hot water in residences that is approved for use based on empirical test data and where the control effectiveness of the device is clearly labeled in terms of its overall reduction of operational waste hot water.

Drain Water Heat Recovery (DWHR) – A heat exchanger unit that uses outgoing warm drain water to pre-heat incoming cold freshwater, is rated for efficiency and pressure loss according to CSA B55.1, and complies with CSA B55.2.

T_{mains} – The temperature of the potable water supply entering the residence.

Add new Normative References to Section 6

CSA B55.1-12, (2012). "Test method for measuring efficiency and pressure loss of drain water heat recovery units." CSA Group, Mississauga, Ontario, Canada L4W 5N6.

CSA B55.2-12, (2012). "Drain water heat recovery units." CSA Group, Mississauga, Ontario, Canada L4W 5N6.

Revise Table 4.2.2(1) as follows:

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

Building Component	HERS Reference Home	Rated Home
Service water heating systems [(i), (n), (p)]	Fuel type: same as Rated Home Efficiency	Same as Rated Home [(n)]
	Electric: EF = 0.97 - (0.00132 * store gal)	Same as Rated Home
	Fossil fuel: EF = 0.67 - (0.0019 * store gal)	Same as Rated Home
	Use (gal/day): ~~$30*N_{du} + 10*N_{br}$)~~ ~~where: N_{du} = number of dwelling units~~ determined in accordance with Section 4.2.2.5.1.4	~~Same as HERS Reference Home~~ Determined in accordance with Section 4.2.2.5.2.11
	Tank temperature: ~~120~~ 125 F	Same as HERS Reference Home

Add new section 4.2.2.5.1.4 and renumber following sections and equations as necessary

4.2.2.5.1.4 Service Hot Water Use. Service hot water system use in gallons per day for the HERS Reference Home shall be determined in accordance with Equation 4.2-2

$$HWgpd = (refDWgpd + refCWgpd + F_{mix} * (refFgpd + refWgpd)) * Ndu \qquad \text{Eq. 4.2-2}$$

where:

HWgpd = gallons per day of hot water use

refDWgpd = reference dishwasher gallons per day = ((88.4+34.9*Nbr)*8.16)/365

refCWgpd = reference clothes washer gallons per day = (4.52*(164+46.5*Nbr))*((3*2.08+1.59)/(2.874*2.08+1.59))/365

$F_{mix} = 1 - ((T_{set} - T_{use})/(T_{set} - T_{mains}))$

where

T_{set} = Water heater set point temperature = 125 F

T_{use} = Temperature of mixed water at fixtures = 105 F

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

where

T_{mains} = temperature of potable water supply entering residence (°F)

$T_{amb,avg}$ = annual average ambient air temperature (°F)

$\Delta T_{amb,max}$ = maximum difference between monthly average ambient temperatures (e.g., $T_{amb,avg,july} - T_{amb,avg,january}$) (°F)

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 = $35 - 1.0 (T_{amb,avg} - 44)$

refFgpd = 14.6 + 10.0*Nbr = reference climate-normalized daily fixture water use in Reference Home (in gallons per day)

refWgpd = $9.8*Nbr^{0.43}$ = reference climate-normalized daily hot water waste due to distribution system losses in Reference Home (in gallons per day)

where

Nbr = number of bedrooms in each dwelling unit

Ndu = number of dwelling units

Modify Section 4.2.2.5.10 as follows:

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 in accordance with Equation 4.2-9a.

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/y) from the 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 = (3.0/2.87~~447~~) * (164 + Nbr*46.5~~45.6~~)

CAPw = washer capacity in cubic feet from the manufacturer's data **or** the CEC database[1] **or** the EPA Energy Star website [2] **or** the default value of 2.874 ft^3

Add new section 4.2.2.5.2.11 and renumber following section and equations as necessary

4.2.2.5.2.11 Service Hot Water Use. Service hot water system use in gallons per day for the Rated Home shall be determined in accordance with Equation 4.2-11

$HWgpd = (DWgpd + CWgpd + F_{eff} * adjF_{mix} * (refFgpd + oWgpd + sWgpd * WD_{eff})) * Ndu$ **Eq. 4.2-11**

where:

HWgpd = gallons per day of hot water use in Rated home

[1] (Informative Reference) http://www.appliances.energy.ca.gov/

[2] (Informative Reference) http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

DWgpd = dishwasher gallons per day (see Section 4.2.2.5.2.9) =
((88.4+34.9*Nbr)*12/dWcap*(4.6415*(1/EF)-1.9295))/365
CWgpd = clothes washer gallons per day (see Section 4.2.2.5.2.10) =
60*((LER*($/kWh)-AGC)/(21.9825*($/kWh)-($/therm))/392)*ACY/365
F_{eff} = fixture effectiveness in accordance with Table 4.2.2.5.2.11(1)

Table 4.2.2.5.2.11(1) Hot water fixture effectiveness

Plumbing Fixture Description	F_{eff}
Standard-flow: showers ≤2.5 gpm and faucets ≤2.2 gpm	1.00
Low-flow: all showers and faucets ≤2.0 gpm	0.95

$adjF_{mix} = 1 - ((T_{set} - T_{use})/ (T_{set} - WH_{in}T))$
where
T_{set} = 125 °F = water heater set point temperature
T_{use} = 105 °F = temperature of mixed water at fixtures
$WH_{in}T$ = water heater inlet temperature
where
$WH_{in}T = T_{mains} + WH_{in}T_{adj}$ for DWHR systems and where $WH_{in}T_{adj}$ is calculated in accordance with equation 4.2-14
$WH_{in}T = T_{mains}$ for all other hot water systems
T_{mains} = temperature of potable water supply entering the residence calculated in accordance with Section 4.2.2.5.1.4
refFgpd = reference climate-normalized daily fixture water use calculated in accordance with Section 4.2.2.5.1.4

$oWgpd = refWgpd * oFrac * (1-oCD_{eff})$ Eq. 4.2-12

where
oWgpd = daily standard operating condition waste hot water quantity
oFrac = 0.25 = fraction of hot water waste from standard operating conditions
oCD_{eff} = Approved Hot Water Operating Condition Control Device effectiveness (default = 0.0)

sWgpd = (refWgpd – refWgpd * oFrac) * pRatio * sysFactor Eq. 4.2-13

where
sWgpd = daily structural waste hot water quantity
refWgpd = reference climate-normalized distribution system waste water use calculated in accordance with Section 4.2.2.5.1.4
oFrac = 0.25 = fraction of hot water waste from standard operating conditions
pRatio = hot water piping ratio
where
for Standard systems:
pRatio = PipeL / refPipeL
where
PipeL = measured length of hot water piping from the hot water heater to the farthest hot water fixture, measured longitudinally from plans, assuming the hot water piping does not run diagonally, plus 10 feet of piping for each floor level, plus 5 feet of piping for unconditioned basements (if any)
$refPipeL = 2*(CFA/Nfl)^{0.5} + 10*Nfl + 5*Bsmt$ = hot water piping length for Reference Home
where
CFA = conditioned floor area
Nfl = number of conditioned floor levels in the residence, including conditioned basements

Bsmt = presence =1.0 or absence = 0.0 of an unconditioned basement in the residence

for recirculation systems:

pRatio = BranchL /10

where

BranchL = measured length of the branch hot water piping from the recirculation loop to the farthest hot water fixture from the recirculation loop, measured longitudinally from plans, assuming the branch hot water piping does not run diagonally

sysFactor = hot water distribution system factor from Table 4.2.2.5.2.11(2)

Table 4.2.2.5.2.11(2) Hot Water Distribution System Insulation Factors

Distribution System Description	**sysFactor**	
	No pipe insulation	≥R-3 pipe insulation
Standard systems	1.00	0.90
Recirculation systems	1.11	1.00

WD_{eff} = distribution system water use effectiveness from Table 4.2.2.5.2.11(3)

Table 4.2.2.5.2.11(3) Distribution system water use effectiveness

Distribution System Description	**WD_{eff}**
Standard systems	1.00
Recirculation systems	0.10

Ndu = number of dwelling units

4.2.2.5.2.11.1 Drain Water Heat Recovery (DWHR) Units

If DWHR unit(s) is (are) installed in the Rated Home, the water heater potable water supply temperature adjustment ($WH_{in}T_{adj}$) shall be calculated in accordance with Equation 4.2-14.

$$WH_{in}T_{adj} = Ifrac*(DWHR_{in}T - T_{mains})*DWHR_{eff}*PLC*LocF*FixF \quad \text{Eq. 4.2-14}$$

where

$WH_{in}T_{adj}$ = adjustment to water heater potable supply inlet temperature (°F)

$Ifrac = 0.56 + 0.015*Nbr - 0.0004*Nbr^2$ = fraction of hot water use impacted by DWHR

$DWHR_{in}T$ = 97 °F

T_{mains} = calculated in accordance with Section 4.2.2.5.1.4

$DWHR_{eff}$ = Drain Water Heat Recovery Unit efficiency as rated and labeled in accordance with CSA 55.1

where

$DWHR_{eff} = DWHR_{eff}$ *1.082 if low-flow fixtures are installed in accordance with Table 4.2.2.5.2.11(1)

PLC = 1 - 0.0002*pLength = piping loss coefficient

where

for standard systems:

pLength = pipeL as measured accordance with Section 4.1.1.5.2.11

for recirculation systems:

pLength = branchL as measured in accordance with Section 4.2.2.5.2.11

LocF = a performance factor based on the installation location of the DWHR determined from Table 4.2.2.5.2.11(4)

Table 4.2.2.5.2.11(4) Location factors for DWHR placement

DRHR Placement	**LocF**
Supplies pre-heated water to both the fixture cold water piping	1.000

and the hot water heater potable supply piping	
Supplies pre-heated water to only the hot water heater potable supply piping	0.777
Supplies pre-heated water to only the fixture cold water piping	0.777

FixF = Fixture Factor
where
FixF = 1.0 if all of the showers in the home are connected to DWHR units

FixF = 0.5 if there are 2 or more showers in the home and only 1 shower is connected to a DWHR unit.

4.2.2.5.2.11.2 Hot Water System Annual Energy Consumption

Service hot water energy consumption shall be calculated using Approved Software Tools and the provisions of Section 4.2.2.5.1.4, Section 4.2.2.5.2.11 and Section 4.2.2.5.2.11.1 shall be followed to determine appropriate inputs to the calculations.

If the Rated Home includes a hot water recirculation system, the annual electric consumption of the recirculation pump shall be added to the total hot water energy consumption. The recirculation pump kWh/y shall be calculated using Equation 4.2-15

pumpkWh/y = pumpW * Efact **Eq. 4.2-15**

where:
pumpW = pump power in watts (default pumpW = 50 watts)
Efact = factor selected from Table 4.2.2.5.2.11(5)

Table 4.2.2.5.2.11(5) Annual electricity consumption factor for hot water recirculation system pumps

Recirculation System Description	Efact
Recirculation without control or with timer control	8.76
Recirculation with temperature control	1.46
Recirculation with demand control (presence sensor)	0.15
Recirculation with demand control (manual)	0.10

Results from standard hot water energy consumption calculations considering only tested Energy Factor data ($stdEC_{HW}$) shall be adjusted to account for the energy delivery effectiveness of the hot water distribution system in accordance with equation 4.2-16.

$EC_{HW} = stdEC_{HW} * (E_{waste} + 128) / 160$ **Eq. 4.2-16**

where E_{waste} is calculated in accordance with equation 4.2-17.

$E_{waste} = oEW_{fact} * (1-oCD_{eff}) + sEW_{fact} * pEratio$ **Eq. 4.2-17**

where
$oEW_{fact} = EW_{fact} * oFrac$ = standard operating condition portion of hot water energy waste
where
EW_{fact} = energy waste factor in accordance with Table 4.2.2.5.2.11(6)
oCD_{eff} is in accordance with Section 4.2.2.5.2.11.1
$sEW_{fact} = EW_{fact} – oEW_{fact}$ = structural portion of hot water energy waste
pEratio = piping length energy ratio
where
for standard system: pEratio = PipeL / refpipeL
for recirculation systems: pEratio = LoopL / refLoopL
and where
LoopL = hot water recirculation loop piping length including both supply and return sides of the loop, measured longitudinally from plans, assuming the hot water

piping does not run diagonally, plus 20 feet of piping for each floor level greater than one plus 10 feet of piping for unconditioned basements.

refLoopL = 2.0*refPipeL - 20

Table 4.2.2.5.2.11(6) Hot water distribution system relative annual energy waste factors

Distribution System Description	EW_{fact}	
	No pipe insulation	≥R-3 pipe insulation
Standard systems	32.0	28.8
Recirculation without control or with timer control	500	250
Recirculation with temperature control	375	187.5
Recirculation with demand control (presence sensor)	64.8	43.2
Recirculation with demand control (manual)	43.2	28.8