BSR/RESNET/ ICC 301-201x

Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index

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Appendix
B

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SPECIAL NOTE

This ANSI/RESNET/ICC 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 2.1, August 25, 2017. RESNET is an American National Standards Institute (ANSI) Accredited Standards Developer. Consensus is defined by ANSI as "substantial agreement reached by directly and materially affected interest categories." This signifies the concurrence 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.

The initial publication of the first edition of this Standard was designated and titled ANSI/RESNET 301-2014 Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using the HERS Index. The designation and title were changed to ANSI/RESNET/ICC 301-2014 Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using an Energy Rating Index as noted in the amendment proceeding for ANSI/RESNET/ICC 301-2014 Addendum B-2015. The second publication of the Standard first edition incorporated the designation and title changes and other non-substantive editorial changes to the first publication. This second edition of the Standard, BSR/RESNET/ICC 301-201x Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using an Energy Rating Index, incorporates a number of substantive changes, the more significant of which are all addenda to the first edition and criteria specific to attached dwelling and attached sleeping units in buildings of all heights.

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 via the online form on the RESNET website. The Manual and online form can be accessed from the website at www.resnet.us/blog/resnet-consensus-standards/ under the heading **STANDARDS DEVELOPMENT**.

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

Contents

BSR/RESNET/ICC 301-201x

Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index

Forward (Informative)

This Standard provides a consistent, uniform methodology for evaluating and labeling the energy performance of Dwelling Units and Sleeping Units, including all detached and attached housing types. The terms dwelling unit and sleeping unit are interchangeable with the term home, except where specifically noted. 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 Energy Rating Index (ERI). Where the energy performance of the actual home and the reference home are equal, the Energy Rating Index is 100 and where the actual home requires no net Purchased Energy annually, the Energy Rating Index is 0 (zero).

The Energy Rating Reference Home used for this comparative analysis has the energy attributes of the 2006 International Energy Conservation Code (IECC) *Standard Reference Design*. Thus, the Energy Rating Index is relative to the minimum building energy efficiency requirements of the 2006 IECC. As a result, the Energy Rating 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 Energy Rating Index for the local standard will be greater than 100 and where local building energy codes are more stringent than the 2006 IECC, the Energy Rating Index for the local standard will be less than 100. Because the Energy Rating Index 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 an Energy Rating Index of 100.

This standard does not provide a methodology for the calculation of an ‘Energy Rating Index’ for a whole building that contains more than one Dwelling Unit or Sleeping Unit. Section 5.1.5 provides a method to calculate a ‘composite Energy Rating Index’ substitute that is allowed to represent the residential portions of a single building that contains more than one Dwelling or Sleeping Unit or a group of multiple Detached Dwelling Units.

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.

The designation and title of the first edition of this Standard were revised effective November 17, 2015. The original designation, “ANSI/RESNET 301-2014,” was revised to “ANSI/RESNET/ICC 301-2014.” The title, “Standard for the Calculation and Labeling of Low-Rise Residential Buildings using the HERS Index,” was revised to “Standard for the Calculation and Labeling of Low-Rise Residential Buildings using the Energy Rating Index.” All references to “HERS” within the Standard were revised to “Energy Rating.” The change in

Rating Index." All references to "HERS" within the Standard were revised to "Energy Rating." The change in designation adds recognition of the International Code Council (ICC) as a sponsor of the Standard. Non-substantive editorial changes to ANSI/RESNET 301-2014 noted in the amendment proceeding for ANSI/RESNET/ICC 301-2014 Addendum B-2015 and in the "Special Note" above were published in that edition.

This is the second edition of the Standard and is the first update in its five year revision cycle. The designation is updated to indicate year 2019 and the title and scope are modified to reflect its expansion to cover dwelling and sleeping units in buildings of any height. The terminology of the title and scope have been revised for consistency with the International Code Council model building codes.

1. Purpose. The provisions of this document establish Energy Rating and labeling Standards, consistent with the provisions of the Energy Policy Act of 1992, which provides for uniformity and consistency in the rating and labeling of Dwelling Units and Sleeping Units in detached and attached housing types.

2. Scope. This standard is applicable to Dwelling Units and Sleeping Units in Residential or Commercial Buildings, excepting hotels and motels. Energy Ratings determined in accordance with this standard are for individual Dwelling Units or Sleeping Units only. This standard does not provide procedures for determining Energy Ratings for whole buildings containing more than one unit.

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.

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 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 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.

Approved Rating Provider – An approved entity responsible for the approval of Approved Testers and Approved Inspectors and the certification of raters working under its auspices and who is responsible for the quality assurance of such Certified Raters and for the quality assurance of Energy Ratings produced by such Certified Raters.

Approved Software Rating Tool – A computerized procedure that is approved for the purpose of conducting Energy Ratings and calculating the annual energy consumption, annual energy costs and an Energy Rating Index for a home.

Approved Inspector – An individual who, by virtue of training and examination, has demonstrated competence in the performance of on-site inspections in accordance with requirements of Appendix A and Appendix B and who has been approved by an Approved Rating Provider to conduct such tests.

Approved Tester – An individual who, by virtue of training and examination, has demonstrated competence in the performance of on-site testing in accordance with requirements of Standard ANSI/RESNET/ICC 380

and who has been approved by an Approved Rating Provider to conduct such tests.

Attached Dwelling Unit – A Dwelling Unit sharing demising walls, floors, ceilings, or common corridors with another Dwelling Unit or Occupiable Space.

Average Dwelling Unit Energy Rating Index – A single, composite Energy Rating Index substitute that can be used to represent the residential portions of a single building. This substitute is established by averaging the Energy Rating Index of each Dwelling Unit in the building and is calculated in accordance with Section **Error! Reference source not found.**.

Auxiliary Electric Consumption – The annual auxiliary electrical energy consumption for a fossil fuel fired furnace, boiler or Ground Source Heat Pump in Kilowatt-Hours per year.

Balanced Ventilation System (Balanced System) – A Ventilation system where the total supply airflow and total exhaust airflow are simultaneously within 10% of their average.

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 – For one- and two-family Dwellings and Townhouses, a room or space 70 square feet of floor area or greater, with egress window or skylight, and doorway to the main body of the Dwelling Unit, that can be used for sleeping. For all other Dwelling Units, a room[5] or space that can be used for sleeping. For all Dwelling or Sleeping Units, the number of bedrooms shall not be less than one.

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 Energy Ratings through certification by an Approved Rating Provider.

Chiller – Vapor compression cooling equipment that uses the outdoor air or water circulated through a Cooling Tower as a heat sink for cooling.

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.

Commercial Building – All buildings that are not included in the definition of Residential Buildings.

Compartmentalization Boundary – The surface area that bounds the Infiltration Volume of the Dwelling Unit.

Conditioned Floor Area (CFA) – The floor area of the Conditioned Space Volume within a building or Dwelling Unit, not including the floor area of attics, crawlspaces, and basements below air sealed and insulated floors. The following specific spaces are addressed to ensure consistent application of this definition:

- The floor area of a wall assembly that is adjacent to Conditioned Space Volume shall be included.
- The floor area of a basement shall be included if the party conducting the evaluation has either:
    - Obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume, or,
    - Verified through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgement of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1).
- The floor area of a garage shall be excluded, even when it is conditioned.
- The floor area of a thermally isolated sunroom shall be excluded.
- The floor area of an attic shall be excluded, even when it is Conditioned Space Volume.
- The floor area of [illegible] shall be excluded [illegible] Conditioned Space Volume

- The floor area of a crawlspace shall be excluded, even when it is Conditioned Space Volume.

Conditioned Space Volume - The volume within a Dwelling Unit serviced by a space heating or cooling system designed to maintain space conditions at 78 °F (26 °C) for cooling and 68 °F (20 °C) for heating. The following specific spaces are addressed to ensure consistent application of this definition:

- If the volume both above and below a floor assembly meets this definition and is part of the Rated Dwelling Unit, then the volume of the floor assembly shall also be included. Otherwise the volume of the floor assembly shall be excluded.
  - Exception: The wall height shall extend from the finished floor to the bottom side of the floor decking above the Rated Dwelling Unit for non-top floor level Dwelling Units and to the exterior enclosure air barrier for top floor level Dwelling Units.
- If the volume of at least one of the spaces horizontally adjacent to a wall assembly meets this definition, and that volume is part of the Rated Dwelling Unit, then the volume of the wall assembly shall also be included. Otherwise, the volume of the wall assembly shall be excluded.
  - Exception: If the volume of one of the spaces horizontally adjacent to a wall assembly is a Dwelling Unit other than the Rated Dwelling Unit, then the volume of that wall assembly shall be evenly divided between both adjacent Dwelling Units.
- The volume of an attic that is not both air sealed and insulated at the roof deck shall be excluded.
- The volume of a vented crawlspace shall be excluded.
- The volume of a garage shall be excluded, even when it is conditioned.
- The volume of a thermally isolated sunroom shall be excluded.
- The volume of an attic that is both air sealed and insulated at the roof deck, the volume of an unvented crawlspace, and the volume of a basement shall only be included if the volume is contiguous with the Rated Dwelling Unit and the party conducting evaluations has either:
  - Obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume, or,
  - Verified through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgement of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1).
- The volume of a mechanical closet, regardless of access location, that is contiguous with the Rated Dwelling Unit shall be included if:
  - it is serviced by a space heating or cooling system designed to maintain space conditions at 78 °F (26 °C) for cooling and 68 °F (20 °C) for heating, and
  - it only includes equipment serving the Rated Dwelling Unit, and
  - ~~combustion makeup air is not intentionally provided from outside the Dwelling Unit, and~~
  - the mechanical room is not intentionally air sealed from the Rated Dwelling Unit.

Confirmed Rating – A Rating accomplished using data gathered from verification of all rated features of the home in accordance with this Standard.

Cooling Tower – A heat rejection device that rejects heat to the atmosphere.

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 that adjusts for the energy losses associated with the delivery of energy from the equipment to the source of the load.

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

Detached Dwelling Unit – A Dwelling Unit that does not meet the definition of Attached Dwelling Unit.

Dwelling **–** Any building that contains one or two Dwelling Units used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or that are occupied for living purposes.

Dwelling Unit **–** A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

Dwelling-Unit Mechanical Ventilation System – A Ventilation system consisting of powered Ventilation equipment such as motor-driven fans and blowers and related mechanical components such as ducts, inlets, dampers, filters and associated control devices that provides dwelling-unit Ventilation at a known or measured airflow rate.

Electric Auxiliary Energy (Eae) – The average annual Auxiliary Electric 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.

Energy Rating **–** An unbiased indication of a Dwelling Unit's relative energy performance based on consistent inspection procedures, operating assumptions, climate data and calculation methods in accordance with this Standard.

Energy Rating Disclosure – A set of assertions attested to by the Certified Rater listing all potential financial interests of the Certified Rater with respect to the property being Rated. Where any potential financial interest in the results of the Rating exists on the part of the Certified Rater, it must be disclosed and attested to in writing by the Certified Rater.

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

Energy Rating 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 Energy Rating Index of a Rated Home.

Energy Rating System – The procedures, rules and guidelines by which Energy Ratings are conducted by an Approved Rating Provider, as specified in these Standards.

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.

Exhaust Ventilation System (Exhaust System) **–** One or more fans that remove air from the Dwelling Unit, causing outdoor air to enter by Ventilation inlets or normal leakage paths through the Dwelling Unit envelope.

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

Failure – When one or more of the Threshold Specifications are not met during inspections or testing.

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 Volume. 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. Normally the simple area calculated as the overall length times the overall width of the enclosure component.

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 is 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.

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.

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.

Index Adjustment Design (IAD) – A home design comprising 2-stories and 3 Bedrooms with Conditioned Floor Area of 2,400 ft^2 used to determine the percentage improvement over the Energy Rating Reference Home for the purposes of determining the Index Adjustment Factor that is applied to the Rated Home.

Index Adjustment Factor (IAF) – A value calculated using the percentage improvement of the Index Adjustment Design to determine the impact of home size, number of Bedrooms and number of stories on the Energy Rating Index of the Rated Home.

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

Infiltration Volume – The sum of the Conditioned Space Volume and additional adjacent volumes in the Dwelling Unit that meet the following criteria:

- Crawlspaces and floor assemblies above crawlspaces, when the access doors or hatches between the crawlspace and Conditioned Space Volume are open during the enclosure airtightness test,
- Attics, when the access doors or access hatches between the attic and Conditioned Space Volume are open during the enclosure airtightness test,
- Basements and floor assemblies above basements, where the doors between the basement and Conditioned Space Volume are open during the enclosure airtightness test.

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, hot water tanks, equipment, appliances, and Miscellaneous Energy Loads internal to the Conditioned Space Volume.

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

kBtu – One thousand British Thermal Units (Btu).

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 refers 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).

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

MBtu – One million British Thermal Units (Btu).

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 an Energy Rating, and which are evaluated by Certified Raters or Approved Inspectors, in accordance with the on-site inspection procedures described in Appendix B, in order to collect the data necessary to create an 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.

Multifamily Buffer Boundary – An unconditioned building space located directly adjacent to the Compartmentalization Boundary of the Dwelling Unit.

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 skylights, 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~~.

Non-Freezing Space – For modeling purposes, the temperature of this space shall float with outside temperature but shall be no lower than 40°F. Applicable only in buildings containing multiple Dwelling Units.

Occupiable Space – A room or enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes or in which occupants are engaged at labor, and which is equipped with means of egress and light and ventilation facilities meeting the requirements of this standard.

On-Site Power Production (OPP) – Electric power produced on 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 of this Standard.

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

Performance Threshold – The specific pass/fail criterion for the inspection or testing of each Minimum Rated Feature, which is based on a predetermined prescriptive or worst-case specification.

Projected Rating – A Rating accomplished using Minimum Rated Feature data derived from plans and specifications.

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

Quality Assurance – The systematic processes intended to ensure reliable compliance with applicable standards.

Qualifying Light Fixture Locations – For the purposes of rating, those light fixtures located within the contiguous area that is for the sole use of the Rated Home occupants, limited to kitchens, dining rooms, living rooms, family rooms/dens, bathrooms, hallways, stairways, entrances, bedrooms, garage, utility rooms, home offices, and all outdoor fixtures mounted on the exterior of the Rated Home or on a pole. This excludes plug-in lamps, closets, unconditioned basements, lighting for common spaces, parking lot lighting, and landscape lighting.

Qualifying Tier I Light Fixture – A light fixture located in a Qualifying Light Fixture Location that contains fluorescent lamps.

Qualifying Tier II Light Fixture – A light fixture located in a Qualifying Light Fixture Location that contains LED lamps; an integrated LED fixture; an outdoor light fixture that is controlled by a photocell; or an indoor fixture controlled by a motion sensor.

Rated Home – The specific real property that is evaluated using the Energy Rating procedures specified by this Standard.

Rating – See Energy Rating.

Reference Home – See Energy Rating Reference Home.

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.

Residential Building – Includes detached one-family Dwellings and two-family Dwellings and multiple single-family Dwellings (Townhouses) and Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane. ~~(See IECC and IBC.)~~

Residual Miscellaneous Energy Loads (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 ($h \cdot ft^2 \cdot {}^oF/Btu$) [$m^2 \cdot K/W$].

Sampled Feature – A building element, component, or group thereof that is evaluated for compliance with Threshold Specifications by using Sampling.

Sampled Project – A building with multiple units or a group of buildings with multiple units to which Sampling is applied.

Sampled Rating – A rating type that encompasses a set of Dwelling Units and is accomplished using data gathered from verification of fewer than 100% of the instances of each minimum rated feature within that set in accordance with this Standard.

Sampling – A process whereby fewer than 100% of the Dwelling Units are inspected, tested, or modeled to demonstrate 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.

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

Sleeping Unit – A room or space in which people sleep, which can also include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also part of a Dwelling Unit are not sleeping units.

Solar Absorptance – The fraction of normal incident solar radiation striking a surface that is not reflected or transmitted.

Specific Leakage Area (SLA) – The unitless ratio of the Effective Leakage Area (ELA) of a home enclosure as defined by ASHRAE Standard 62.2 divided by the home's Conditioned Floor Area, given in the same units of measure.

Supply Ventilation System (Supply System) – One or more fans that supply outdoor air to the Dwelling Unit. Supply Ventilation systems shall be designed and constructed to provide Ventilation air directly from the outdoors to the Dwelling Unit.

Threshold Specifications – A set of qualification criteria that are established based on a Worst-Case Analysis of an explicit design specification.

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

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

Townhouse - A single-family Dwelling Unit constructed in a group of three or more attached units in which each unit extends from the foundation to roof and with open space on at least two sides.

Typical Existing Home – A representation of existing U.S. housing stock that assumes standard operating conditions and which is assigned an Energy Rating 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 ($Btu/h \cdot ft^2 \cdot {}^oF$) [$W/m^2 \cdot K$].

Unconditioned Space Volume – The volume within a building or Dwelling Unit that is not Conditioned Space Volume but which contains heat sources or sinks that influence the temperature of the area or room. The following specific spaces are addressed to ensure consistent application of this definition:

- If either one or both of the volumes above and below a floor assembly is Unconditioned Space Volume, then the volume of the floor assembly shall be included.
- If the volume of both of the spaces horizontally adjacent to a wall assembly are Unconditioned Space Volume, then the volume of the wall assembly shall be included.
- The volume of an attic that is not both air sealed and insulated at the roof deck shall be included.
- The volume of a vented crawlspace shall be included.
- The volume of a garage shall be included, even when it is conditioned.
- The volume of a thermally isolated sunroom shall be included.
- The volume of an attic that is both air sealed and insulated at the roof deck, the volume of an unvented crawlspace, and the volume of a basement shall be included unless it meets the definition of Conditioned Space Volume.

Uniform Energy Factor (UEF) – DOE's standard for communicating the energy efficiency of water heaters.

Unrated Conditioned Space – A building location used only in ratings of attached units, beyond the boundaries of the rated Dwelling Unit and serviced by a space heating or cooling system designed to maintain space conditions at 78 °F (26 °C) ± 5°F for cooling and 68 °F (20 °C) ± 5°F for heating. The energy for conditioning Unrated Conditioned Space is not counted in the Rated Home or Energy Rating Reference Home. This is distinct from Unrated Heated Space, and from Conditioned Space Volume.

Unrated Heated Space – A building location used only in ratings of attached units for shared service equipment such as shared laundry, heating, cooling, hot water, or ventilation. Unrated Heated Space is outside of the Conditioned Space Volume and only interacts with the Rated Home via the shared services located within. The energy for heating the Unrated Heated Space is not counted in the Rated Home or Energy Rating Reference Home.

Variable Refrigerant Flow Multi-Split Air Conditioning and Heat Pump Equipment (VRF) – Commercial-grade air conditioning or Heat Pumps with variable refrigerant flow that use the outdoor air as the heat source or sink (see also Heat Pump).

Ventilation – The process of providing outdoor air directly to a Dwelling Unit by natural or mechanical means. Such air may or may not be conditioned.

Water Loop Heat Pump (WLHP) – Vapor compression heating and cooling equipment that uses water as its heat source and heat sink (see also Heat Pump).

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 at least 5 ACH of indoor air to the outdoors thereby drawing outdoor air into a home through open windows and doors for the purpose of cooling the home.

Window Film – Fenestration attachment products which consist of a flexible adhesive-backed polymer film which is 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 Dwelling Unit are configured to provide the largest Energy Rating Index when four ordinal home orientations and the least energy efficient Minimum Rated Features for the specified design are considered by the Analysis.

3.3. Acronyms.

ACH – Air Changes per Hour

ACH50 – Air Changes per Hour at 50 Pascals

AFUE – Annual Fuel Utilization Efficiency

AHRI - Air-Conditioning, Heating, and Refrigeration Institute

ASHP – Air Source Heat Pump

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

CEC – California Energy Commission

CFA – Conditioned Floor Area

CFIS – Central Fan Integrated Supply

cfm – Cubic Feet per Minute

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

DWHR – Drain Water Heat Recovery

Eae – Electric Auxiliary Energy

EER – Energy Efficiency Ratio

EF – Energy Factor

ELA – Effective Leakage Area

EPA – U.S. Environmental Protection Agency

EPAct 92 – Energy Policy Act of 1992

ERI – Energy Rating Index

FF – Framing Fraction

gpm – Gallons per Minute

GSHP – Ground Source Heat Pump

HSPF – Heating Seasonal Performance Factor

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

HVAC – Heating, Ventilating and Air Conditioning

IAD – Index Adjustment Design

IAF – Index Adjustment Factor

IBC –International Building Code

ICC – International Code Council

IDR – Innovative Design Request

IECC – International Energy Conservation Code

IMEF – Integrated Modified Energy Factor

IPIA – In-Plant Inspection Agency

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

IRS – U.S. Internal Revenue Service

kWh – Kilowatt-Hour

MELs – Miscellaneous Energy Loads

MEPR – Manufacturer's Equipment Performance Rating

NAECA – National Appliance Energy Conservation Act

NREL – National Renewable Energy Laboratory

OPP - On-Site Power Production

Pa – Pascal

RESNET – Residential Energy Services Network, Inc.

SEER – Seasonal Energy Efficiency Ratio

SHW – Service Hot Water

SL – Standby Loss

SLA – Specific Leakage Area

SRCC – Solar Rating & Certification Corporation

TE – Thermal Efficiency

TPO – Thermoplastic polyolefin

UEF – Uniform Energy Factor

VRF – Variable refrigerant flow

WLHP – Water Loop Heat Pump

4. Energy Rating Calculation Procedures.

4.1. Determining the Energy Rating Index. The Energy Rating Index for a Rated Home shall be determined in accordance with Sections 4.1.1 and 4.1.2. This standard shall not be used to calculate the Energy Rating Index for a whole building that contains more than one Dwelling Unit or Sleeping Unit.

4.1.1. Calculating End Use Loads. The normalized Modified End Use Loads (nMEUL) for space heating and cooling and service 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 less than 0.80 occurs 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 4.1.1(1) below:

Table 4.1.1(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 Energy Rating Index. The Energy Rating Index shall be determined in accordance with Equation 4.1-2:

$$\textbf{Energy Rating Index} = PEfrac * (TnML / (TRL * IAF_{RH})) * 100 \qquad \textbf{(Eq. 4.1-2)}$$

where:

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

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

IAF_{RH} = Index Adjustment Factor of Rated Home, per Eq. 4.3-2

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 4.2.2.6 of this Standard.

$$\textbf{kWh}_{eq} = (\textbf{Btu}_{fossil} * 0.40) / 3412 \qquad \textbf{(Eq. 4.1-3)}$$

4.2. Energy Rating Reference Home and Rated Home Configuration.

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

4.2.2. Residence Specifications. The Energy Rating 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 Energy Rating Reference and Rated Homes

Building Component	Energy Rating Reference Home	Rated Home
Above-grade walls	Type: wood frame	Same as 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 Space Volume, Non-Freezing Space 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 ANSI/CRRC S100. Emittance values provided by the roofing manufacturer in accordance with ANSI/CRRC S100 shall be used when available. In cases where the appropriate data are not known, same as the Reference Home.
Attics	Type: vented with aperture = 1ft^2 per 300 ft^2 ceiling area	Same as Rated Home
Foundations	Type: same as Rated Home Gross Area: same as Rated Home U-Factor / R-Value: from Table 4.2.2(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Crawlspaces	Type: vented with net free vent aperture = 1ft^2 per 150 ft^2 of crawlspace floor area. Crawlspace walls shall be uninsulated, while the floor above the crawlspace shall be insulated according to Table 4.2.2(2) as a "Floor over Unconditioned Space Volume" [q]. U-factor: from Table 4.2.2(2) for floors over Unconditioned Space Volume 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 for one- and two-family Dwellings and Townhouses;	Same as Rated Home

	Dwellings and Townhouses; 20 ft^2 for all others Orientation: For exterior doors: North For all other doors, in adiabatic wall U-factor: same as Fenestration from Table 4.2.2(2)	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 Energy Rating Reference Home [c] Same as Rated Home [p]
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, supplemented as necessary to achieve the required Dwelling-Unit total air exchange rate (Qtot).[f], [g]	In accordance with Standard ANSI/RESNET/ICC 380, obtain airtightness test results for: • Building enclosure (for Detached Dwelling Units) • Compartmentalization Boundary (for Attached Dwelling Units). For Attached Dwelling Units with airtightness test results ≤ 0.30 cfm50 per ft^2 of Compartmentalization Boundary, the test results shall be multiplied by reduction factor A_{ext} [r] to determine the Infiltration rate. For Attached Dwelling Units with airtightness test results > 0.30 cfm50 per ft^2 of Compartmentalization Boundary, the test results shall be modeled as the Infiltration rate. For residences without Dwelling-Unit Mechanical Ventilation Systems, or without measured airflow, or where A_{ext} [r] < 0.5 and the Mechanical Ventilation System is solely an Exhaust System, the Infiltration rate [e] shall be as determined above, but not less than 0.30 ACH.

		For residences with Dwelling-Unit Mechanical Ventilation Systems, the total air exchange rate shall be the Infiltration rate [e] as determined above, in combination [g] with the time-averaged Dwelling-Unit Mechanical Ventilation System rate,[f], [t] which shall be the value measured in accordance with Standard ANSI/RESNET/ICC 380.~~, but~~ The Dwelling-Unit Mechanical Ventilation System rate shall be increased as needed to ensure that the total air exchange rate is no less than Qtot = 0.03 x CFA + 7.5 x (Nbr+1) cfm
Dwelling-Unit Mechanical Ventilation System fan energy	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 Dwelling-Unit Mechanical Ventilation System: 0.35*fanCFM*8.76 kWh/y Where Rated Home has balanced Dwelling-Unit Mechanical Ventilation System without energy recovery or a combination of Supply and Exhaust Systems: 0.70* fanCFM*8.76 kWh/y Where Rated Home has balanced Dwelling-Unit Mechanical Ventilation System with energy recovery: 1.00*fanCFM*8.76 kWh/y And where fanCFM is the minimum continuous Dwelling Unit Mechanical Ventilation System fan flow rate[f] for the Rated Home[y].	Same as Rated Home [u], [x]
Internal Gain	As specified by Table 4.2.2(3)	Same as Energy Rating Reference Home, except as provided by Section 4.2.2.5.2
Internal mass	An internal mass for furniture and contents of 8 pounds per square foot of floor area	Same as Energy Rating 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 R2 carpet and pad, and 20% of floor directly exposed to room air	Same as Rated Home

	exposed to room air For masonry basement walls, same as Rated Home, but with insulation required by Table 4.2.2(2) located on the interior side of the walls For other walls, for ceilings, floors, and interior walls, wood frame construction	Same as Rated Home Same as Rated Home
Heating systems [i], [j]	Fuel type: same as Rated Home Efficiencies: Electric: Air Source Heat Pump in accordance with Table 4.2.2(1a) Non-electric furnaces: natural gas furnace in accordance with Table 4.2.2(1a) Non-electric boilers: natural gas boiler in accordance with Table 4.2.2(1a) Capacity: sized in accordance with Section 4.4.3.1.	Same as Rated Home [j] Same as Rated Home Same as Rated Home Same as Rated Home Same as Rated Home [s]
Cooling systems [i], [k]	Fuel type: Electric Efficiency: in accordance with Table 4.2.2(1a) Capacity: sized in accordance with Section 4.4.3.1.	Same as Rated Home [k] Same as Rated Home Same as Rated Home [s]
Service water heating systems [i], [l], [n],[o]	Fuel type: same as Rated Home Efficiency: Electric: EF = 0.97 - (0.00132 * store gal) Fossil fuel: EF = 0.67 - (0.0019 * store gal) Use (gal/day): Determined in accordance with Section 4.2.2.5.1.4 Tank temperature: 125 °F	Same as Rated Home [l] Same as Rated Home Same as Rated Home Determined in accordance with Section 4.2.2.5.2.11 Same as Energy Rating 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: • ~~Detached Dwelling Units shall test duct leakage to outside;~~ • ~~Attached Dwelling Units requiring testing[w] shall test total duct leakage or duct leakage to outside;~~ ~~All duct leakage tests shall be~~ Tested in accordance with requirements of Standard ANSI/RESNET/ICC 380[m] and ~~the energy impacts~~ then either calculated through hourly simulation or calculated in accordance with ASHRAE Standard 152 with the ducts located and insulated

		as in the Rated Home[w]. For ductless distribution systems: DSE=1.00 For hydronic distribution systems: DSE=1.00 ~~For untested distribution systems in Attached Dwelling Units located entirely within Conditioned Space Volume: DSE=0.88~~
Thermostat	Type: manual Temperature setpoints: cooling temperature setpoint = 78 ºF; heating temperature set point = 68ºF	Type: Same as Rated Home Temperature setpoints: same as the Energy Rating Reference Home, except as required by Section 4.4.1

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 Volume. 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) 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 Volume from Unconditioned Space Volume, 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 Unrated Conditioned Space, not including foundation walls.
AG + exterior door area shall not exceed the exterior wall area, and the Energy Rating Reference Home door area shall be reduced as necessary to ensure this.

(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) SLA = ELA / CFA where ELA = 0.054863*cfm50 and where CFA is in square inches.

(e) Envelope (for Detached Dwelling Units) or Compartmentalization Boundary (for Attached Dwelling Units) leakage shall be tested and documented in accordance with requirements of Standard ANSI/RESNET/ICC 380 by an Approved Tester.

(f) The required Dwelling-Unit Mechanical Ventilation System airflow rate (Qfan) shall be determined in accordance with the following equation. Where this requires the Rated Home mechanical ventilation rate to be adjusted in the simulation, and where the Ventilation air is pre-conditioned as part of a shared Ventilation system shared by multiple Dwelling Units, the software shall make corresponding adjustments to the shared preconditioning equipment energy consumption assigned to the Rated Home.

$$Qfan = Qtot - \Phi\ (Qinf \times Aext)$$

where
Qfan = required mechanical Ventilation rate, cfm
Qtot = total required Ventilation rate, cfm
Qinf = infiltration, cfm calculated using Shelter Class 4
Aext = 1 for Detached Dwelling Units, or the ratio of exterior enclosure surface area that is not attached to garages or other Dwelling Units to Compartmentalization Boundary for Attached Dwelling Units
Φ=1 for Balanced Ventilation Systems and *Qinf / Qtot* otherwise

and where
Qtot = 0.03*CFA + 7.5*(Nbr+1), AND
Qinf = 0.0521*cfm50*wsf*(H/Hr)^0.4
OR
Qinf = (NL · wsf · CFA) / 7.3

where
NL = normalized leakage = 1000 · (ELA / CFA) · [H / Hr]^z (where both *ELA* and *CFA* are in square inches)
wsf = weather and shielding factor from Appendix B, ASHRAE Standard 62.2
ELA = cfm50*0.054863 (in^2)
H = vertical distance between lowest and highest above-grade points within the pressure boundary (ft.)
Hr = reference height = 8.202 ft.

(g) Either hourly calculations using the following equation or calculations yielding equivalent results shall be used to determine the combined air exchange rate resulting from Infiltration in combination with Dwelling-Unit Mechanical Ventilation Systems.

$$Qi = Qfan,i + \Phi\ Qinf,i$$

where
Φ=1 for Balanced Ventilation Systems and otherwise
$\Phi = Qinf,i\ /(\ Qinf,i + Qfan,i\ )$
Qi = combined air exchange rate for the time step 'i', cfm
Qinf,i = Infiltration airflow rate for the time step 'i', cfm calculated using Shelter Class 4
Qfan,i = mechanical Ventilation airflow rate for the time step 'i', cfm

(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. 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 Energy Rating 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). Energy Rating 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.		

(j) 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 Energy Rating 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 Energy Rating Reference Home and Rated Home.

(k) 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 Energy Rating Reference Home and the Rated Home.

(l) For a Rated Home with a non-storage-type water heater or where a shared water heater provides service hot water to the Rated Home, a 40-gallon storage-type water heater of the same fuel as the proposed water heater shall be assumed for the Energy Rating Reference Home. For tankless water heaters with an Energy Factor, EF shall be multiplied by 0.92 for Rated Home calculations. For tankless water heaters with a Uniform Energy Factor, UEF shall be multiplied by 0.94 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 Energy Rating Reference Homes. In both cases the Energy Factor of the water heater shall be as prescribed for the Energy Rating Reference Home water heater by Table 4.2.2(1).

(m) Duct leakage shall be tested by an Approved Tester in accordance with requirements of Standard ANSI/RESNET/ICC 380-2016 or equivalent.

Exception: The requirement to test for duct leakage to the outside shall be waived, and the ducts shall be assigned 0 (zero) leakage to outside, if both of the following conditions are visually verified by an Approved Tester at the final stage of construction.

i. All ductwork and the air handler unit are completely within the Infiltration Volume of the home.
ii. All ductwork is visible

(n) The Uniform Energy Factor (UEF) or Energy Factor (EF) shall be obtained for residential hot water equipment, or the Thermal Efficiency (TE) and Standby loss (SL) shall be obtained for commercial hot water equipment, from manufacturer's literature or from AHRI directory for equipment being used, where available. For commercial water heaters, where EF or UEF is not available, an Approved commercial hot water system calculator shall be used to determine the EF or UEF.

water system calculator shall be used to determine the EF or UEF.

Where a manufacturer provided or AHRI published EF or UEF is not available for the residential hot water equipment, the guidance provided in i shall be used to determine the effective EF of the water heater. Where a manufacturer provided or AHRI published TE or SL is not available for commercial hot water equipment, the guidance provided in ii shall be used to determine the effective TE and SL of the water heater.

i. For residential oil, gas and electric water heaters or Heat Pumps, default EF values provided in Table 4.5.2(3) for age-based efficiency or Table 4.5.2(4) for non-age-based efficiency shall be used.
ii. For commercial water heaters, values provided in Table C404.2 Minimum Performance of Water-Heating Equipment in the ~~2015~~ IECC shall be used.

(o) The heat sources and sinks associated with the Service Hot Water System shall be included in the energy balance for the space in which the Service Hot Water System is located.

(p) The term External Shading refers only to permanent, fixed shading devices attached to the building such as fins and overhangs. Window screens, movable awnings, roller shades, safety bars, balcony railings, and shade from adjacent buildings, trees and shrubs shall not be included in the analysis of the Rated Home energy usage.

(q) This applies to the Reference Home crawlspace, regardless of the crawlspace type or insulation location in the Rated Home crawlspace.

(r) Reduction factor A_{ext} (used only for Attached Dwelling Units) shall be the ratio of exterior envelope surface area to Compartmentalization Boundary.

(s) When the Rated Home is in a building with multiple Dwelling Units, and where Dwelling-Unit Mechanical Ventilation System supply air is pre-conditioned by a shared system before delivery to the Dwelling Unit, that shared pre-conditioning system shall be represented in the Rated Home simulation as a separate HVAC system, in addition to the primary space conditioning system serving the Dwelling Unit. The supply airflow delivered to the Rated Home is the only conditioning load that shall be assigned to that shared equipment, and shall be determined as described in Table 4.2.2(1), endnote (t). Accordingly, the capacity of the simulated pre-conditioning equipment shall be the actual capacity pro-rated by the ratio of Rated Home supply airflow divided by total airflow through the actual shared pre-conditioning equipment.

(t) Where a shared mechanical Ventilation system serving more than one Dwelling Unit provides any Dwelling-Unit Mechanical Ventilation, the following shall be used to determine the Ventilation airflows in the Rated Home.

1. Where shared Ventilation supply systems provide a mix of recirculated and outdoor air, the supply Ventilation airflow shall be adjusted to reflect the percentage of air that is from outside.
2. Where the Dwelling-Unit Mechanical Ventilation System is a Supply System or an Exhaust System, and not a Balanced System nor a combination of systems, the Ventilation rate shall be the value measured in the Rated Home or adjusted in accordance with the previous step.
3. Where the Dwelling-Unit Mechanical Ventilation System is a Balanced System or a combination of systems, the system airflows shall be analyzed separately, in accordance with the previous steps. For software that does not explicitly model multiple, separate Supply and Exhaust Systems, the Dwelling-Unit Mechanical Ventilation System shall be modeled as a Balanced System, where the Ventilation rate of the Rated Home is the sum of either the exhaust airflows measured in the Dwelling Unit or the sum of the supply airflows measured in the unit, whichever is greater.

(u) Dwelling-Unit Mechanical Ventilation System fan watts shall be the value observed in the Rated Home for the highest airflow setting. Where not available, fan watts shall be based on Table 4.2.2(1b) for the given system. For systems other than Central Fan Integrated Supply (CFIS), where the airflow cannot be measured, the cfm used to determine fan watts shall be assumed to be equal to Qfan, as determined in accordance with endnote (f) of Table 4.2.2 (1). For CFIS systems, the cfm used to determine fan watts shall be the larger of 400 cfm per 12 kBtu/h cooling capacity or 240 cfm per 12 kBtu/h heating capacity.

Table 4.2.2(1b). Default Ventilation System Fan Power for Rated Home

Equipment Type	Watts/ cfm
Exhaust ventilation fans	0.35
Supply ventilation fans	0.35
Balanced ventilation fans	0.70
HRV/ERV fans	1.00
CFIS fans	0.50
Range hoods	0.70

~~(v) Total duct leakage or duct leakage to outside testing is only required for any Attached Dwelling Unit where any portion of the ducts or air handler are located outside of Conditioned Space Volume. Attached Dwelling Units with ducts and air handlers inside the Conditioned Space Volume are permitted to test and use tested duct leakage results in the Rated Home or use the default DSE=0.88.~~

~~(w) For Attached Dwelling Units only: Software shall calculate the energy impact of total duct leakage results by counting leakage only from duct surface area that is not in Rated Home Conditioned Space Volume, plus a contribution from the associated air handler if located outside the Rated Home Conditioned Space Volume. When located outside the Rated Home Conditioned Space Volume, the air handler contribution shall be a minimum of 2.5% of the supply airflow, where supply airflow is calculated as 400 cfm per 12,000 Btu/h of output capacity of the heating or cooling equipment; however, the sum shall not exceed the measured duct leakage from the entire duct system.~~

(x) Where the Ventilation system is designed to serve the Ventilation needs of more than one Dwelling Unit, the Rated Home kWh/y fan energy shall be calculated as a proportion of the entire system fan energy, using the system airflow, Ventilation type, fan run time and the rated fan power of the shared system. The Rated Home ventilation fan energy shall be calculated as the fan power of the entire system multiplied by the ratio of Dwelling Unit airflow to the system airflow. Where the system fan power cannot be determined, 1 Watt/cfm shall be used. Where the Dwelling Unit airflow cannot be measured, the Rated Home shall use Qfan, as determined in accordance with endnote (f) of Table 4.2.2 (1) when calculating fan energy.

(y) Where rating software allows for modeling of multiple or hybrid Ventilation system types, the Reference Home mechanical Ventilation fan energy shall be calculated proportionally using the Ventilation system types employed in the Rated Home. The fan CFM contribution of each system type shall be proportional to the product of the airflow and the runtime of each Ventilation system type.

Table 4.2.2(2). Component Heat Transfer Characteristics for Energy Rating 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:

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 that are within the Conditioned Space Volume.
(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 Energy Rating 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 [d]	5,955		168			
TVs	3,861		645			
Range/Oven (elec) [b] [d]	2,228		262	248		29
Range/Oven (gas) [b] [d]	4,086		488	1,037		124
Clothes Dryer (elec) [b] [d]	661		188	73		21
Clothes Dryer (gas) [b] [d]	738		209	91		26
Dishwasher [d]	219		87	219		87
Clothes Washer [d]	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.
(d) When any of these appliances associated with a Rated Home is located in Unrated Heated Space, Unrated Conditioned Space, or otherwise outside of and away from the Dwelling Unit, the Internal Gains associated with that appliance shall be excluded from both the Reference and Rated Homes.

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 or White TPO	0.50
All others	0.92

4.2.2.1. All enclosure element Framing Fractions shall be in accordance with Table 4.2.2(5).

Table 4.2.2(5) Default Framing Fractions for Enclosure Elements		
Enclosure Element	**Frame Spacing (in o.c.)**	**Default Frame Fraction (% area)**
Walls (standard):		
@16" o.c.	16	23%
@24" o.c.	24	20%
Walls (advanced):		
@16" o.c.	16	19%
@24" o.c.	24	16%
Structural Insulated Panels	48	10%
Floors (standard):		
@16" o.c.	16	13%
@24" o.c.	24	10%
Floors (advanced):		
@16" o.c.	16	11%
@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 insulation shall be rated as Grade I, II, or III in accordance with the on-site inspection procedures in Appendix A.

4.2.2.2.1. The insulation of the Energy Rating Reference Home enclosure elements shall be modeled as Grade I. The insulation of the Rated Home shall either be inspected according to procedures in Appendix A 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 Energy Rating inspection where the manufacturer of the home includes the on-site inspection procedures for insulation details and requirements in Appendix A in their DAPIA packages, which are used by IPIAs for their factory inspections.

(b) The R-Values for non-structural materials or for Structural Insulated Panels (SIPs), Insulated Concrete Forms (ICFs), and other pre-manufactured assemblies when accompanied by supporting test data consistent with ASTM C177, ASTM C518, ASTM C1114, ASTM C1363 or ASTM C976.

4.2.2.2.2. Insulation Assessment: Insulated surfaces categorized as “Grade I” shall be modeled such that the insulation R-Value is considered at its measured (for loose fill) or labeled value, including other adjustments, 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, 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, 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 Handbook of 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, including 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, ASHRAE Handbook of Fundamentals or tested in accordance with ASTM Standard C1363. Modification of test results to add or subtract R-Values to the tested assembly that reflect differences between the tested assembly and proposed assemblies is authorized when such differences are continuous and occur outside of the cavity.

4.2.2.3. Renewable Energy Systems 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, Miscellaneous Energy Loads (MELs), Ventilation and Service Hot Water Systems.

4.2.2.5.1. Energy Rating Reference Home. Lighting, Appliance and Miscellaneous Energy Loads in the Energy Rating 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:

$$\text{kWh (or therms) per year} = a + b*CFA + c*Nbr \qquad \text{(Eq. 4.2-1)}$$

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 Energy Rating Reference Home lighting, appliance and Miscellaneous Energy 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 Energy Loads in electric Energy Rating Reference Homes

End Use Component	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	529		150
Dishwasher	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 has gas appliances, those appliances in the Energy Rating Reference Home shall be determined in accordance with the natural gas and electric appliance loads provided below in Table 4.2.2.5(2), as applicable for each appliance.

Table 4.2.2.5(2) Natural Gas Appliance Loads for Energy Rating 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 Energy Rating 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, for the sole use of the occupants of the Rated Home, 100 kWh/y shall be added to the energy use of the Reference Home to account for garage lighting. Lighting for shared parking garages or parking lots shall not be

Home to account for garage lighting. Lighting for shared parking garages or parking lots shall not be included in the Reference Home.

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

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

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 (ºF)

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

$\Delta T_{amb,max}$ = maximum difference between monthly average ambient temperatures (ºF)

0.986 = degrees/day (360/365)

day# = Julian day of the year (1-365)

offset = 6°F

ratio = $0.4 + 0.01 (T_{amb,avg} - 44)$

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

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

where

Nbr = number of Bedrooms in the Rated Home, not to be less than 1.

4.2.2.5.1.5. Ceiling Fans. Where ceiling fans are included in the Rated Home they shall also be included in the Reference Home in accordance with the provisions of Section 0.

4.2.2.5.2. Energy Rating Rated Homes. The lighting, appliance, hot water heating, and Miscellaneous Energy Loads in the Energy Rating Rated Home shall be determined in accordance with Sections 4.2.2.5.2.1 through 0. For a Rated Home without a refrigerator, dishwasher, range/oven, clothes washer or clothes dryer, the values from Table 4.2.2.5(1) shall be assumed for both the Energy Rating Reference Home and Rated Home.

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 Energy Rating 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 4.2-3:

$$kWh/y = 0.9/0.925*(455 + 0.8*CFA) *[(1 - FFI_{int} - FFI_{ext}) + FFI_{int} *15/60 + FFI_{ext} *15/90]$$

[(1 - FFI_{IL} - FFI_{IL}) + FFI_{IL} 15/60 + FFI_{IL} 15/90]
+ 0.1*(455 + 0.8*CFA) **(Eq. 4.2-3)**

where:

CFA = Conditioned Floor Area

FFI_{IL} = The ratio of the interior Tier I Qualifying Light Fixtures to all interior light fixtures in Qualifying Light Fixture Locations.

$FFII_{IL}$ = The ratio of the interior Tier II Qualifying Light Fixtures to all interior light fixtures in Qualifying Light Fixture Locations.

For the purpose of adjusting the annual interior lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by $DEUL_{IL}$, 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 Energy Rating 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 $DEUL_{IL}$ converted to Btu/day as follows: $DEUL_{IL}$ * 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 4.2-4:

kWh/y = (100 + 0.05*CFA)*[(1 - FFI_{EL} - $FFII_{EL}$)
+ 15/60~~*(100 + 0.05*CFA)~~*FFI_{EL}
+ 15/90~~*(100 + 0.05*CFA)~~*$FFII_{EL}$] **(Eq. 4.2-4)**

where

CFA = Conditioned Floor Area

FFI_{EL} = Fraction of exterior fixtures that are Tier I Qualifying Light Fixtures

$FFII_{EL}$ = Fraction of exterior fixtures that are Tier II Qualifying Light Fixtures

For the purpose of adjusting the annual exterior lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by $DEUL_{EL}$, 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 Energy Rating 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, for the sole use of the occupants of the Rated Home, garage annual lighting energy use in the Rated Home shall be determined in accordance with Equation 4.2-5:

kWh = 100*[(1 - FFI_{GL} - $FFII_{GL}$) + 15/60*FFI_{GL} + 15/90*$FFII_{GL}$] **(Eq. 4.2-5)**

where:

FFI_{GL} = Fraction of garage fixtures that are Tier I Qualifying Light Fixtures

$FFII_{GL}$ = Fraction of garage fixtures that are Tier II Qualifying Light Fixtures

Lighting for shared parking garages or parking lots shall not be included in the Rated Home.

For the purpose of adjusting the annual garage lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by $DEUL_{GL}$, 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 Energy Rating 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 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
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 Energy Rating 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 Volume, Unrated Heated Space, Unrated Conditioned Space, or outdoor environment.

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 Energy Rating 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 4.2-6a through 4.2-6c, as appropriate.

1) For electric cooking:
kWh/y = BEF * OEF * (331 + 39*Nbr) (Eq. 4.2-6a)

2) For natural gas cooking:
Therms/y = OEF*(22.6 + 2.7*Nbr) (Eq. 4.2-6b)
plus:
kWh/y = 22.6 + 2.7*Nbr (Eq. 4.2-6c)

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 Energy Rating 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.

Internal Gains shall not be modified for range/oven equipment located outside the Rated Home.

4.2.2.5.2.8. Clothes Dryers. Clothes Dryer annual energy use for the Rated Home shall be determined in accordance with Equation 4.2-7 and shall be based on the clothes dryer located within the Rated Home. If no clothes dryer is located within the Rated Home, a clothes dryer in the nearest shared laundry room on the project site shall be used, if available for daily use by the occupants of the Rated Home. If the shared laundry room has multiple clothes dryers, the clothes dryer with the lowest EF or CEF shall be used.

kWh/y = 12.5*(164+46.5*Nbr)*FU/EFdry*(CAPw/MEF - LER/392)/(0.2184*(CAPw*4.08+0.24)) (Eq 4.2-7)

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 **or** the default value of 3.01 **or** calculated as 1.15*CEF.
CEF = Combined Energy Factor is the clothes dryer efficiency (lbs dry clothes/kWh) based on current U.S. DOE clothes dryer testing procedures.
CAPw = Capacity of clothes washer (ft^3) from the manufacturer's data **or** the CEC Appliance

CAP w = Capacity of clothes washer (ft^3) from the manufacturer's data **or** the CEC Appliance Efficiency Database **or** the EPA ENERGY STAR website **or** the default value of 2.874 ft^3.

MEF = Modified Energy Factor of clothes washer from the Energy Guide label **or** the default value of 0.817 **or** calculated as 0.503+0.95*IMEF.

IMEF = Integrated Modified Energy Factor, which has replaced MEF as the U.S. DOE Energy Factor test metric for clothes washers.

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 4.2-8a and 4.2-8b.

Therms/y = (result of Eq. 4.2-7)*3412*(1-0.07)
***(3.01/EFdry-g)/100000 (Eq. 4.2-8a)**
kWh/y = (result of Eq. 4.2-7)*0.07*(3.01/EFdry-g) (Eq. 4.2-8b)

where:

EFdry-g = Efficiency Factor for gas clothes dryers **or** the default value of 2.67 **or** calculated as 1.15*CEF.

CEF = Combined Energy Factor is the clothes dryer efficiency based on current U.S. DOE clothes dryer testing procedures.

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 Energy Rating 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.

When a Dwelling Unit has no in-unit clothes dryer, and no shared clothes dryers are available in the building or on the project site for daily use by the Rated Home occupants or they exist, but the ratio of Dwelling Units to shared clothes dryers is greater than 14, the clothes dryer values from Table 4.2.2.5(1) shall be assumed for both the Energy Rating Reference Home and Rated Home.

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 Volume, Unrated Heated Space, Unrated Conditioned Space, or outdoor environment.

4.2.2.5.2.9. Dishwashers. Dishwasher annual energy use for the Rated Home shall be determined in accordance with Equation 4.2-9a and shall be based on the dishwasher located within the Rated Home, with the lowest Energy Factor (highest kWh/y). If no dishwasher is located within the Rated Home, a dishwasher in the nearest shared kitchen in the building shall be used, only if available for daily use by the occupants of the Rated Home.

kWh/y = [(86.3 + 47.73/EF)/215]*dWcpy (Eq. 4.2-9a)

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 4.2-9b.

ΔGPD_{DW} = [(88.4+34.9*Nbr)*8.16 - (88.4+34.9*Nbr)
***12/dWcap*(4.6415*(1/EF) - 1.9295)]/365 (Eq. 4.2-9b)**

For the purpose of adjusting the annual dishwasher energy consumption for calculating the rating, EUL_{LA} shall be adjusted by $DEUL_{DW}$, 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 Energy Rating 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.

When a Dwelling Unit has no in-unit dishwasher, and no shared dishwashers are available in the building for daily use of the Rated Home occupants, the energy and hot water use of the Rated Home dishwasher shall be the same as the Energy Rating Reference Home, in accordance with Section 4.2.2.5.1.

For dishwasher energy use, total Internal Gains in the Rated Home shall be modified by 60% of the dishwasher $DEUL_{DW}$ converted to Btu/day as follows: $DEUL_{DW} * 10^6 / 365$. Of this total amount, 50% shall be apportioned to sensible Internal Gains and 50% to latent Internal Gains.

Internal Gains shall not be modified for dishwashers located outside the Rated Home.

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, and shall be based on the clothes washer located within the Rated Home. If no clothes washer is located within the Rated Home, a clothes washer in the nearest shared laundry room on the project site shall be used, if available for daily use by the occupants of the Rated Home. If the shared laundry room has multiple clothes washers, the clothes washer with the highest LER shall be used.

Annual energy use shall be calculated in accordance with Equation 4.2-10a.

kWh/y = [(LER/392)-[(LER*($/kWh)-AGC)/(21.9825*($/kWh)
- ($/therm)]/392)*21.9825)]*ACY (Eq. 4.2-10a)

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 = (3.0/2.874) * (164 + Nbr*46.5)
    - CAPw = washer capacity in cubic feet from the manufacturer's data **or** the CEC Appliance Efficiency Database **or** the EPA ENERGY STAR website **or** the default value of 2.874 ft^3

Daily hot water use shall be calculated in accordance with Equation 4.2-10b.

CWgpd = 60 * therms/cyc * ACY / 365 (Eq. 4.2-10b)

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 Energy Rating 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 the gallons per day derived for the Energy Rating Reference Home clothes washer in Section 4.2.2.5.1.4.

When a Dwelling Unit has no in-unit clothes washer, and no shared clothes washers are available in the building or on the project site for daily use by the Rated Home occupants or they exist, but the ratio of Dwelling Units to shared clothes washers is greater than 14, the energy and hot water use of the Rated Home clothes washer shall be the same as the Energy Rating Reference Home, in accordance with Section 4.2.2.5.1.

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 modified for clothes washers located in Unconditioned Space Volume, Unrated Heated Space, Unrated Conditioned Space, or outdoor environment.

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 4.211

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

where:

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

DWgpd = dishwasher gallons per day

= ((88.4+34.9*Nbr)*12/dWcap*(4.6415*(1/EF)-1.9295))/365

CWgpd = clothes washer gallons per day = 60*((LER*($/kWh)-AGC)/(21.9825*($/kWh)

-($/therm))/392)*ACY/365

Where more than one water heater exists in a Rated Home or building, the DWgpd load and CWgpd load must be attributed to the water heater providing that appliance with hot water.

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 Operational 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 (or from a shared recirculation loop serving multiple Dwelling Units) 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 Dwelling Unit, including conditioned basements
Bsmt = presence = 1.0 **or**
= absence = 0.0 of an unconditioned basement in the Dwelling Unit
for recirculation systems (entirely within the Rated Home):
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) [43]

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

4.2.2.5.2.11.1. Drain Water Heat Recovery (DWHR) Units

If DWHR unit(s) is (are) installed and serve 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.

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

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 4.2.2.5.2.11

for recirculation systems (entirely within the Rated Home):

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

DWHR Placement	LocF
Supplies pre-heated water to both the fixture cold water piping and the hot water heater potable supply piping	1.000
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 either within the Dwelling Unit or in the form of a shared recirculation system serving multiple Dwelling Units, then 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 4.2-15a for recirculation systems located completely within the Dwelling Unit. The shared recirculation pump kWh/y shall be calculated using Equation 4.2-15b for shared recirculation systems serving multiple Dwelling Units.

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

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

$SharedHWpumpkWh/y = SHWP_{kW} * OpHrs/Ndweq$ **(Eq. 4.2-15b)**

where:

$SHWP_{kW}$= Shared HW pump power in kW. Convert HP to kW with the formula:

kW = HP x 0.746 / motor efficiency. If pump motor efficiency is unknown, use 0.85. If HP is unknown, use 0.25.

OpHrs = annual pump operating hours

= 730 [for demand control]

= 8760 [without control or with timer control]

N_{dweq}= number of Dwelling Units served by the shared HW pump

Results from standard hot water energy consumption 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 $sEW_{fact} = EW_{fact} – oEW_{fact}$ = structural portion of hot water energy waste

pEratio = piping length energy ratio

where

for standard system: pEratio = PipeL / refpipeL

for recirculation systems (entirely within the Rated Home):

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

4.2.2.5.2.12. Ceiling Fans. Where the number of ceiling fans included in the Rated Home is equal to or greater than the number of Bedrooms plus one, 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 ºF. The cooling thermostat (but not the heating thermostat) shall be set up by 0.5 ºF 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 4.2-18.

LCFSW = (3000cfm) / (cfm/Watt as labeled at medium speed) (Eq. 4.2-18)

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.

4.2.2.5.2.13 Dwelling-Unit Mechanical Ventilation System Fans. If Dwelling-Unit 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. On-Site Power Production. The Energy Rating Reference Home shall not include On-Site Power Production. Where the project site includes On-Site Power Production (OPP), the total OPP shall be computed as the electric energy produced on the project site minus the equivalent electric energy use (kWheq) calculated in accordance with Equation 4.1-3 of any purchased fossil fuels used to produce the

total OPP. The total OPP shall be pro-rated to individual Dwelling Units based on the number of Bedrooms where the per-Bedroom OPP is used to determine the Dwelling Unit OPP that is used in the determination of PEfrac.

4.3. Index Adjustment Factor (IAF). The IAF for each Rated Home shall be determined in accordance with Sections 4.3.1 through 4.3.4.

4.3.1. Index Adjustment Design (IAD). An IAD shall be configured in accordance with Table 4.3.1(1). Renewable Energy Systems that offset the energy consumption requirements of the Rated Home shall not be included in the IAD.

Table 4.3.1(1) Configuration of Index Adjustment Design

Building Component	Index Adjustment Design (IAD)
General Characteristics	Number of Stories (NS): Two (2) Number of Bedrooms (Nbr): Three (3) Conditioned Floor Area (CFA): 2400 ft^2 Number of conditioned zones: One (1) No attached garage Wall height: 17 feet (including band joist) Wall width: 34.64 feet facing N, S, E and W All heating, cooling, and hot water equipment shall be located in Conditioned Space Volume.
Foundation	Type: Vented crawlspace Venting: net free vent aperture = 1ft^2 per 150 ft^2 of crawlspace floor area. Gross floor area: 1200 ft^2 Floor U-Factor: Same as Energy Rating Reference Home Foundation wall: 2 feet tall, 2 feet above-grade Wall width: 34.64 feet facing N, S, E and W Wall U-Factor: Same as Energy Rating Reference Home
Above-grade walls	Type: Same as Rated Home. If more than one type, maintain same proportional coverage for each type, excluding any garage wall, Multifamily Buffer Boundary wall, adiabatic wall, and sealed attic gable-end wall areas. U-Factor: Same as Rated Home Solar Absorptance: Same as Rated Home Emittance: Same as Rated Home
Ceilings	Type: Same as Rated Home. If more than one type, maintain same proportional coverage for each type. Gross projected footprint area: 1200 ft^2 U-Factor: Same as Rated Home
Roofs	Type: Same assembly details as Rated Home. The geometry shall be a hip roof with no gable-end walls. If more than one type, maintain same proportional coverage for each type. Gross Area: 1300 ft^2 Solar Absorptance: 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 ANSI/CRRC S100. Emittance: Same as Rated Home Emittance values provided by the roofing manufacturer in accordance with ANSI/CRRC S100 shall be used when available. In cases where the appropriate data are not known, same as the Energy Rating Reference Home.
Attics	Type: Same as Rated Home. If more than one type, maintain same

	proportional coverage for each type.
Doors	Area: Same as Rated Home Orientation: Same as Rated Home U-Factor: Same as Rated Home
Glazing	Total area =Same as Energy Rating Reference Home Orientation: equally distributed to four (4) cardinal compass orientations (N,E,S,&W) U-Factor: Area-weighted average U-Factor of Rated Home SHGC: Area-weighted average SHGC of Rated Home Interior shade coefficient: Summer: Same as Energy Rating Reference Home Winter: Same as Energy Rating Reference Home External shading: None
Skylights	Same as Rated Home
Thermally isolated sunrooms	Same as Rated Home
Air exchange rate	Combined [a] Infiltration flow rate plus mechanical ventilation flow rate of 0.03 * CFA + 7.5 * (Nbr+1) cfm ~~and with energy loads calculated in quadrature~~ Infiltration flow rate shall be determined using the following envelope leakage rates: 5 ACH_{50} in IECC Climate Zones 1-2 3 ACH_{50} in IECC[48] Climate Zones 3-8
Dwelling-Unit Mechanical Ventilation System fan energy	Balanced Ventilation System without energy recovery and with fan power = 0.70 * fanCFM * 8.76 kWh/y
Internal Gains	As specified by Table 4.2.2(3) except that lighting shall be 75% high efficiency
Internal mass	An internal mass for furniture and contents of 8 pounds per square foot of floor area
Structural mass	Same as Energy Rating Reference Home
Heating systems	Fuel type: Same as Rated Home Efficiencies: Electric: Air Source Heat Pump in accordance with Table 4.2.2(1a) Non-electric furnaces: natural gas furnace in accordance with Table 4.2.2(1a) Non-electric boilers: natural gas boiler in accordance with Table 4.2.2(1a) Capacity: sized in accordance with Section 4.4.3.1
Cooling systems	Fuel type: Electric Efficiency: in accordance with Table 4.2.2(1a) Capacity: sized in accordance with Section 4.4.3.1
Service water heating systems	Fuel type: same as Rated Home Efficiency: Electric: EF = 0.97 - (0.00132 * store gal) Fossil fuel: EF = 0.67 - (0.0019 * store gal) Use: Same as Energy Rating Reference Home Tank temperature: 125 F
Thermal distribution	Thermal Distribution System Efficiency (DSE) of 1.00 shall be

Thermal distribution systems	Thermal Distribution System Efficiency (DSE) of 1.00 shall be applied to both the heating and cooling system efficiencies and air distribution systems shall be located within Conditioned Space Volume
Thermostat	Type: manual Temperature set points: cooling temperature set point = 78 F; heating temperature set point = 68 F
Lighting, Appliances and Miscellaneous Energy Loads (MELs)	Same as the Energy Rating Reference Home, except that lighting shall be 75% Tier I

Table 4.3.1(1) Notes:

(a) Either hourly calculations using the following equation or calculations yielding equivalent results shall be used to determine the combined air exchange rate resulting from Infiltration in combination with the Dwelling-Unit Mechanical Ventilation Systems.

$Qi = Qfan,i + \Phi\ Qinf,i$

where
Φ=1 for Balanced Ventilation Systems and otherwise
$\Phi = Qinf,i /(Qinf,i + Qfan,i)$
Qi = combined air exchange rate for the time step 'i', cfm
$Qinf,i$ = Infiltration airflow rate for the time step 'i', cfm calculated using Shelter Class 4
$Qfan,i$ = mechanical Ventilation airflow rate for the time step 'i', cfm

4.3.2. An Approved Software Rating Tool shall be used to determine the Energy Rating Index for the IAD (ERI_{IAD}).

4.3.3. The saving represented by the IAD shall be calculated using Equation 4.3-1.

$$\mathbf{IAD_{SAVE} = (100 - ERI_{IAD}) / 100} \qquad \textbf{(Eq. 4.3-1)}$$

4.3.4. The IAF for the Rated Home (IAF_{PD}) shall be calculated in accordance with Equation 4.3-2.

$$\mathbf{IAF_{RH} = IAF_{CFA} * IAF_{Nbr} * IAF_{NS}} \qquad \textbf{(Eq. 4.3-2)}$$

where:
IAF_{RH} = combined Index Adjustment Factor for Rated Home
$IAF_{CFA} = (2400/CFA)\ ^\wedge\ [0.304 * (IAD_{SAVE})]$
$IAF_{Nbr} = 1+ [0.069 * (IAD_{SAVE}) * (Nbr-3)]$
$IAF_{NS} = (2/NS)\ ^\wedge\ [0.12 * (IAD_{SAVE})]$
where:
CFA = Conditioned Floor Area
Nbr = Number of Bedrooms
NS = Number of stories

4.4. 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 4.4.1 through 4.4.9.

4.4.1. Programmable Thermostats. Where programmable offsets are available in the Rated Home, 2 ºF 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;

schedule for cooling, and with no offsets assumed for the Reference Home;

4.4.2. Local Climate. The climatologically most representative TMY3 or equivalent climate data.

4.4.3. HVAC Sizing. Manufacturer's Equipment Performance Ratings 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 Handbook of Fundamentals, or an equivalent computation procedure, using the following assumptions:

4.4.3.1. Energy Rating Reference Home:

4.4.3.1.1. Indoor temperatures shall be 75 ºF for cooling and 70 ºF for heating.

4.4.3.1.2. 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.

4.4.3.1.3. The adjusted total air exchange rate (Qtot, adj) in cubic feet per minute (cfm) shall be the product of 1.4 and the value determined by Equation 4.4-1 ~~and 1.4~~.

$$Qtot = 0.03 * CFA + 7.5*(Nbr+1) \quad \textbf{(Eq. 4.4-1)}$$

4.4.3.1.4. 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.

4.4.3.1.5. Internal 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.

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

4.4.3.1.7. Systems shall not be larger than the size calculated using this procedure plus 100 Btu/hr.

4.4.3.2. Rated Home:

4.4.3.2.1. Indoor temperatures shall be 75 ºF for cooling and 70 ºF for heating.

4.4.3.2.2. 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.

4.4.3.2.3. The total air exchange rate (Qtot) in cubic feet per minute (cfm) shall be the product of 1.4 and the larger of the value determined by Equation 4.4-1 and the infiltration rate in cfm as determined by testing in accordance with Standard ANSI/RESNET/ICC 380 (and after adjustment by A_{ext} where directed by Table 4.2.2(1) for Attached Dwelling Units).

4.4.3.2.4. Where a Dwelling-Unit Mechanical Ventilation System(s) is provided, the combined total air exchange rate (infiltration rate and mechanical ventilation fan rate) shall not be less than the total ventilation rate determined by the product of the value determined by Equation 4.4-1 and 1.4. Flow rates for bathroom, kitchen and other local exhaust that does not serve as a component of a Dwelling-Unit Mechanical Ventilation System shall not be considered for sizing purposes.

4.4.3.2.5. 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.)

4.4.3.2.6. 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.

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

4.4.3.2.8. To the degree that the installed equipment capacity for the Rated Home exceeds equipment properly sized in accordance with the above procedures, the impact of the over-sizing on part-load performance shall be accounted accordingly.

4.4.3.2.9. When Dwelling-Unit Mechanical Ventilation System supply air is conditioned before delivery to the Rated Home by a system serving more than one Dwelling Unit, the ventilation supply air shall be apportioned to the shared mechanical ventilation system that actively conditions it, as described in Table 4.2.2(1), endnote (s). The ventilation conditioning load is the only space conditioning load that shall be assigned to that shared equipment.

4.4.4. Air Source Heat Pumps and Air Conditioners.

4.4.4.1. 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, including compressor and distribution fan/blower; and crank case heater, shall then be added together to obtain the total energy uses for heating and cooling.

4.4.4.2. For a Chiller, model the Rated Home cooling system efficiency (SEER) using the rated efficiency of the Chiller with allowance for circulation pumps and fans according to the following formula:

(Eq. 4.4-2)

Where:

Cap = Chiller system output in Btu/hour

aux = Total of the pumping and fan power serving the system in Watts. Convert HP to Watts with the formula:

Watts = HP x 746 / motor efficiency. If motor efficiency is unknown, use 0.85

aux_{dweq} = Total of the in-unit cooling equipment power serving the Dwelling Unit in Watts

Input = Chiller system power in Watts

N_{dweq} = Number of Dwelling Units served by the shared system.

4.4.4.3. For a Cooling Tower with WLHP's, model the Rated Home cooling system efficiency (SEER) using the rated efficiency of the WLHP (EER) with allowance for the Rated Home's portion of the in-building circulation pumps and cooling fans and circulation pumps according to the following formula:

(Eq. 4.4-3)

Where:

$WLHP_{cap}$ =WLHP cooling capacity in Btu/hour

aux = Total of the pumping and fan power serving the system in Watts. Convert HP to Watts with the formula:

Watts = HP x 746 / motor efficiency. If motor efficiency is unknown, use 0.85

Input = WLHP system power in Watts using the formula:

Where: *EER*=Energy Efficiency Ratio of the WLHP

N_{dweq} = Number of Dwelling Units served by the shared system.

4.4.5. 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 Consumption for the Rated Home shall be determined as follows:

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

where:

$GSHP_{pump}$ in Watts is the observed pump nameplate data (Volt*Amps) that shall be added for all periods of Heat Pump operation. Amps are taken from the nameplate as either 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 are allowed to be substituted. Such measured pumping energy is allowed to 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, $GSHP_{fan}$ = (airflow in cfm * 0.2 Watts per cfm), shall be added for all periods of Heat Pump operation. The airflow in cfm shall be (400 * rated cooling Btu/h / 12,000), where 400 is the airflow in cfm per ton (12 kBtu/h) of capacity. Note that for the purposes of calculating adjusted equipment efficiency, $GSHP_{fan}$ shall also be added to the rated heating capacity, and subtracted from the rated cooling capacity of the equipment. For that adjustment, $GSHP_{fan}$ shall be converted to Btu/h by Btu/h = $GSHP_{fan}$ * 3.412.

For the purpose of projected ratings only, where $GSHP_{pump}$ cannot be determined, the following adjustments shall 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^3 - 0.0531*COP^2 + 0.976*COP

4.4.5.1. Ground Source Heat Pumps on a shared Hydronic Circulation Loop

For multiple ground-loop and ground-water water-to-air Heat Pumps that are shipped with an integral blower fan, and which share common circulation pump(s), the Auxiliary Electric Consumption for the Rated Home shall be determined as follows:

(Eq. 4.4-4)

Where:

SP_{kW} = Shared Pump power in kW. Convert HP to kW with the formula:

kW = HP x 0.746 / motor efficiency. If pump motor efficiency is unknown, use 0.85.

N_{dweq} = Number of Dwelling Units served by the shared system

HLH = Annual Heating Load Hours

CLH = Annual Cooling Load Hours

$HPfan_{kW}$ = Heat Pump distribution fan power in kW

4.4.6. Fossil Fuel Fired Furnaces and Boilers Serving One Unit. For a fossil fuel fired furnace or boiler, the Auxiliary Electric Consumption for the Rated Home shall be determined as follows:

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

where:

HLH = annual heating load hours attributed to the furnace/boiler.

Note: If fan power is needed (kW), it is determined by Eae / 2080.

4.4.7. Fossil Fuel Fired Boilers Serving more than One Unit.

4.4.7.1. Where heat is distributed by baseboard, radiant heat, convectors, or fan coils, the Auxiliary Electric Consumption for the Rated Home shall be determined as follows:

(Eq. 4.4-5)

Where:

SP_{kW} = Shared pump power in kW. Convert HP to kW with the formula:

kW = HP x 0.746 / motor efficiency. If pump motor efficiency is unknown, use 0.85.

HLH = annual heating load hours

N_{dweq} = number of Dwelling Units served by the shared system

aux_{in} = In-unit fan coil kW

The Reference Home shall have a boiler that is sized to the Reference Home heating load, in accordance with Section 4.4.3.1. The Rated Home shall have a boiler that is sized to the Rated Home heating load, in accordance with Section 4.4.3.2.

4.4.7.2. Where heat is distributed by Water Loop Heat Pumps within the Dwelling Unit, the Auxiliary Electric Consumption for the Rated Home shall be determined in accordance with Equation 4.4-5, with the value of aux_{in} set to 0.

4.4.7.2.1. The Rated Home shall be configured such that the heating load is assigned to two separate heating systems: 1) a Heat Pump with a capacity that is equal to the Rated Home design load (as calculated in accordance with Section 4.4.3.2) divided by the rated COP of the Water Loop Heat Pump and 2) a boiler with the balance of the capacity of (1-1/COP).

4.4.7.2.2. The Reference Home shall have a heating equipment that is equal to the Reference Home

4.4.7.2.2. The Reference Home shall have heating equipment that is sized to the Reference Home heating load (in accordance with Section 4.4.3.1), both a Heat Pump and a boiler, sized to the same proportions of the heating load as the heat pump and boiler in Section 4.4.7.2.1.

4.4.8. 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.-For Attached Dwelling Units, where no operable Glazing is present in the Rated Home, Natural Ventilation shall not be included in either the Reference Home or the Rated Home.

4.4.9. Whole-House Fans. When a Whole-House fan is present in the Rated Home 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).

4.5. 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 4.5.2(1).

4.5.1. Data Sources. If data for the Minimum Rated Features set forth in Section 4.5.2 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.

4.5.2. Standard Features. The Minimum Rated Features associated with the home shall be determined and documented by a Certified Rater or Approved Inspector in accordance with Sections 4.5.2.1 through 4.5.2.3 and the on-site inspection procedures in Appendix A and Appendix B.

4.5.2.1. The envelope thermal characteristics of building elements 1 through 8 set forth in Table 4.5.2(1) shall be determined by site observation. Where thermal characteristics cannot be determined during site observation, the manufacturer's data sheet shall be used.

4.5.2.2. The air leakage and duct leakage values set forth as building elements 9 and 10 in Table 4.5.2(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).

4.5.2.3. The energy efficiency of the mechanical equipment set forth as building elements 11, 12 and 14 in Table 4.5.2(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) Nameplate 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 4.5.2(2); 4.5.2(3); 4.5.2(4) and 4.5.2(5).

Table 4.5.2(1) Minimum Rated Features

Building Element	Minimum Rated Feature
General Project Info	Total number of buildings, Dwelling Units, and total number of Bedrooms in the project.

1. Floor/Foundation Assembly	Construction type (slab-on-grade, crawlspace, basement), boundary condition (adiabatic, above unconditioned space, above Non-Freezing Space), dimensions, insulation type, value, and location (edge, under slab, cavity, sheathing), framing material and on-center spacing, insulation installation (Grade I, II, or III), vented or unvented (crawlspace), capacitance (if slab or basement receives appreciable solar gain).
2.Walls Assembly	Construction type, boundary condition (adiabatic, ambient, Multifamily Buffer Boundary), insulation value (cavity, sheathing), framing material and on-center spacing, insulation installation (Grade I, II, or III), capacitance, exterior 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/Band Joists or Floor Perimeters	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), operable/inoperable, shading due to permanent, fixed shading devices attached to the building such as fins and overhangs. Window screens, security bars, balcony railings, movable awnings, roller shades, and shade from adjacent buildings, trees and shrubs shall not be included.
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. Air Leakage	Air leakage measurement and type (default estimate, blower door test), Infiltration Volume, Conditioned Space Volume.
10. Distribution System	System type, location, insulation value (duct and pipe), air leakage measurement and type (default estimate, duct pressurization).
11. Heating Equipment	Equipment type, location, capacity, efficiency (AFUE, HSPF, COP), Electric Auxiliary Energy (Eae), power rating of ground fluid circulating pump(s) for ground-loop and ground-water Heat Pumps, power rating of pumping system for shared boiler distribution.
12. Cooling Equipment	Equipment type, location, capacity, efficiency (SEER, COP, kW/ton), power ratings for the following: Cooling Tower (sprayer pump(s) and fan motor), outdoor system circulation loop pump, indoor system circulation loop pump and Cooling Tower fan/blower and circulation pump.
13. Control Systems	Thermostat type.
14. Service Hot Water Equipment	For Residential Equipment - Equipment type, location, Energy Factor or Uniform Energy Factor, extra tank insulation R-value, flow rates of showers and faucets. For Commercial Equipment - Equipment type, location, Uniform Energy Factor or Thermal Efficiency and Standby Loss, extra tank insulation value, flow rates of showers and faucets.

	Distribution Related: Distribution System Type (standard, recirculation), Recirculation System controls [none, timer, temperature, demand (manual) or demand (sensor)], pipe insulation R-value, pipe length for standard distribution, branch length for recirculation, supply + return loop length, pump power (Watts, HP).
15.Solar Domestic Hot Water Equipment	System type, collector type and area, orientation, tilt, efficiency, storage tank size, pipe insulation value.
16. Light Fixtures	Number of Qualifying Tier I, Tier II, and non-Qualifying Light Fixtures in Qualifying Light Fixture Locations within the contiguous area that is for the sole use of the Rated Home occupants, including 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, unconditioned basements, lighting for common spaces, parking lot lighting, and landscape lighting.
17. Refrigerator(s)	Total annual energy consumption (kWh) for all refrigerators located within the Rated Home and any refrigerators outside the Rated Home for daily use by the Rated Home occupants 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 dishwashers located within the Rated Home and any dishwashers outside the Rated Home intended for daily use by the Rated Home occupants 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	Location, source of hot water, type (residential or commercial); Labeled 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 Appliance Efficiency Database or the EPA ENERGY STAR website, for all clothes washers located within the Rated Home or any clothes washers in the building intended for use by the Rated Home occupants, as defined in Section 4.2.2.5.2.10.
21. Clothes Dryer	Location, clothes washer Modified Energy Factor(MEF) or Integrated Modified Energy Factor (IMEF) and clothes washer Labeled Energy Rating (kWh/y) from Energy Guide label; clothes washer capacity from manufacturer's data or CEC Appliance Efficiency Database or EPA ENERGY STAR website; and clothes dryer Efficiency Factor (EF) or Combined Efficiency Factor (CEF) from CEC Appliance Efficiency Database or EPA ENERGY STAR website, for all clothes dryers located in the Rated Home or any clothes dryers in the building intended for use by the Rated Home occupants, as defined in Section 4.2.2.5.2.8.
22. Ceiling Fans	Total number of ceiling fans in the Dwelling Unit, Labeled cfm, Watts, and cfm/Watt at medium fan speed from each ceiling fan label.
23. Dwelling-Unit Mechanical Ventilation System(s)	Ventilation strategy (Supply, Exhaust, or Balanced), equipment type (individual or shared), daily run hours, measured exhaust airflow, measured supply airflow, system rated airflow, and fan wattage. Where shared systems occur, include percentage of outdoor air in

	supply air, rated exhaust airflow and rated supply airflow of the shared systems. Fan motor efficiency and horsepower are acceptable substitutes for fan wattage.
24. Systems pre-conditioning Ventilation Air	System type (heating, cooling, both), efficiency, fan power, system rated airflow.
25. On-site Power Production	System type, total annual kWh generation, and total site fuel used in the On-Site Power Production as derived from manufacturer's performance ratings.

Table 4.5.2(2) Default Solid Fuel Combustion Seasonal Efficiencies for Space Heating

Type	Location	Seasonal Efficiency	Notes
EPA-Listed Stove, Furnace or Boiler	Conditioned Space Volume or Unrated 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 Volume	0.85 of EPA listing	
EPA Stove – Not Listed	Conditioned Space Volume or Unrated Conditioned Space	60%	For stoves with documented EPA compliance, but not found on EPA's website list of certified stoves
EPA Stove – Not Listed	Unconditioned Space Volume	50%	For stoves with documented EPA compliance, but not found on EPA's website list of certified stoves
EPA-Listed Stove Insert	Enclosed	Subtract 10% from listed seasonal efficiency	
Non-EPA Stove	Conditioned Space Volume or Unrated Conditioned Space	50%	Not tested or listed by EPA
Non-EPA Stove	Unconditioned Space Volume	40%	Not tested or listed by EPA
Biomass Fuel Furnace or Boiler with Distribution System	Conditioned Space Volume or Unrated 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 Volume	40%	Not tested or listed by EPA Distribution System Efficiency shall also be considered
Biomass Fuel Furnace or Boiler with Distribution System	Outside	30%	Not tested or listed by EPA Distribution System Efficiency shall also be considered

Solid Fuel Furnace or Boiler – Independently Tested	Central with ducted or hydronic distribution	0.85 of tested listing	Only permitted with documentation of independent testing lab documentation Distribution System Efficiency shall also be considered

Table 4.5.2(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
Water Loop Heat Pump	COP	3.25	3.25	3.25	3.57	3.70	3.83	4.23	4.36
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
Water Loop Heat Pump	EER	7.73	7.73	7.73	10.30	10.30	11.16	12.88	12.70
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

(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 4.5.2(4) Default Values for Mechanical System Efficiency (not Age-based) [(a)]

Efficiency (not Age-based)

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
Shared Chiller	kW/ton	0.7
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 4.5.2(5) Default Eae Values	
System Type	**Eae**
Oil boiler	330
Gas boiler (serves one unit)	170
Gas boiler (shared, in-unit baseboard)	220
Gas boiler (shared, in-unit WLHP)	265
Gas boiler (shared, in-unit fan coil)	438
Oil furnace	439 + 5.5 * Capacity (kBtu/h)
Gas furnace	149 + 10.3 * Capacity (kBtu/h)

4.6. Existing Home Retrofit Savings. Energy savings for Existing Home Retrofits shall be determined by comparing a Baseline Existing Home Model with an Improved Home Model in accordance with the provisions of this section.

4.6.1. 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 Model shall be based on the original home configuration following the provision of Section 4.2.2.5.2.

4.6.1.1. 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.

4.6.1.2. 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.

4.6.2. 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.

4.6.2.1. Where an existing appliance 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.

4.6.2.2. 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.

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

4.6.3. Standard Operating Conditions.

4.6.3.1. Both the Baseline Existing Home Model and Improved Home Model shall be configured and modeled in accordance with the Rated Home specifications of Table 4.2.2(1). The configuration of the Baseline Existing Home Model shall not violate the specified input constraints in Table 4.6.3(1).

Table 4.6.3(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.	

4.6.3.2. Air Distribution Systems.

4.6.3.2.1. In cases where the air distribution system leakage is not measured in the original Baseline Existing Home Model, 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

distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled in both the Baseline Existing Home Model and the Improved Home Model 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 within the Conditioned Space Volume, the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled in both the Baseline Existing Home Model and the Improved Home Model 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.

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

4.6.3.2.2.1. For the Baseline Existing Home Model, 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 Model 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.

4.6.3.2.2.2. For the Improved Home Model, 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 Model, 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.

4.6.3.3. Both the Baseline Existing Home Model and the Improved Home Model shall be subjected to the operating conditions specified by Section 4.4.

4.6.4. Energy Savings Calculation.

4.6.4.1. Energy units used in the calculation of energy savings shall be the total Dwelling Unit energy use of all fuels (kWh_{tot}) calculated in accordance with Equation 4.6-1.

$$\mathbf{kWh_{tot} = kWh_{elec} + kWh_{eq}} \qquad \textbf{(Eq. 4.6-1)}$$

where

kWh_{tot} = total Dwelling Unit energy use of all fuels used by the home

kWh_{elec} = Dwelling Unit electric energy used by the home

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

4.6.4.2. Dwelling Unit energy savings (kWh_{tot}) shall be calculated as the difference between the total Dwelling Unit energy use (kWh_{tot}) of the Baseline Existing Home Model and the total Dwelling Unit energy use (kWh_{tot}) of the Improved Home Model.

4.6.4.3. The energy savings percentage of the retrofit shall be calculated as the Dwelling Unit total energy savings (kWh_{tot}) as determined by Section 4.6.4.2 divided by the Dwelling Unit total energy use (kWh_{tot}) of the Baseline Existing Home Model.

4.7. 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 4.7-1 and 4.7-2.

$$\mathbf{LCC_F = P1*(1^{st}\ Year\ Energy\ Costs)} \qquad \textbf{(Eq. 4.7-1)}$$

LCC_I = P2*(1st Cost of Improvements) **(Eq. 4.7-2)**

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:

$LCC_S = LCC_{E,b} - LCC_{E,i}$ **(Eq. 4.7-3)**

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:

SIR = (LCC_S) / (LCC_I) **(Eq. 4.7-4)**

NPV = LCC_S - LCC_I **(Eq. 4.7-5)**

where:

SIR = Present Value Savings to Investment Ratio

NPV = Net Present Value of Improvements

4.7.1. Calculation of Ratio Parameters. The ratios represented by parameters P1 and P2 shall be calculated in accordance with Equations 4.7-6a through 4.7-8d.:

P1 = 1/(DR-ER)*(1-((1+ER)/(1+DR))^nAP) **(Eq. 4.7-6a)**

or if DR = ER then

P1 = nAP / (1+DR) **(Eq. 4.7-6b)**

where:

P1 = Ratio of Present Value Life Cycle Energy Costs to the 1st year Energy Costs

DR = Discount Rate as prescribed in Section 4.7.2

ER = Energy Inflation Rate as prescribed in Section 4.7.2

nAP = number of years in Analysis Period as prescribed in Section 4.7.2

$P2 = DnPmt + P2_A + P2_B + P2_C - P2_D$ **(Eq. 4.7-7)**

where:

P2 = Ratio of Life Cycle Improvement Costs to the first cost of improvements

DnPmt = Mortgage down payment rate as prescribed in Section 4.7.2

$P2_A$ = Mortgage cost parameter

$P2_B$ = Operation & Maintenance cost parameter

$P2_C$ = Replacement cost parameter

$P2_D$ = Salvage value cost parameter

$P2_A$ = (1-DnPmt)*(PWFd/PWFi) **(Eq. 4.7-8a)**

where:

PWFd = Present Worth Factor for the discount rate = 1/DR*[1-(1/(1+DR)^nAP)]

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 4.7.2
MR = Mortgage Interest Rate as prescribed in Section 4.7.2
nAP = number of years of the Analysis Period as prescribed in Section 4.7.2
nMP = number of years of the Mortgage Period

$P2_B$ = MFrac*PWinf (Eq. 4.7-8b)

where:
MFrac = annual O&M costs as a fraction of first cost of improvements
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 4.7.2

$P2_C$ = Sum {1/[(1+(DR-GR))^(Life*i)]} for i=1, n (Eq. 4.7-8c)

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

$P2_D$ = RLFrac / ((1+DR)^nAP) (Eq. 4.7-8d)

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

4.7.2. Standard Economic Inputs. The economic parameter values used in the cost effectiveness calculations specified in Section 4.7.1 shall be determined in accordance with Sections 4.7.2.1 through 4.7.2.10.

4.7.2.1. 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, where ACR shall be calculated in accordance with Equation 4.7-9:

ACR = [(endVal)/(startVal)]^[1.0/((endYr)-(startYr))]-1.0 (Eq. 4.7-9)

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

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

4.7.2.3. 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.

4.7.2.4. Down Payment Rate (DnPmt) shall be defaulted to 10% of 1^{st} 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.

4.7.2.5. 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 as calculated using Equation 4.79.

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

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

4.7.2.8. Remaining Life Fraction (RLFrac) shall be calculated in accordance with Equation 4.7-10.

RLFrac = (nAP/Life) – [Integer (nAP/Life)] **(Eq. 4.7-10)**

or if Life > nAP then

RLFrac = (Life-nAP) / nAP

where:

Life = useful service life of the improvement(s)

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

4.7.2.9.1. 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.

4.7.2.9.2. 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.

4.7.2.10. 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. This section establishes minimum uniform standards for certifying and labeling home energy performance using the Energy Rating Index. These include minimum requirements of the 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 are performed in accordance with this Standard.

5.1. Rating Requirements.

5.1.1. General. The Energy Rating for a home shall be determined in accordance with Sections 5.1.1.1 through 5.1.1.4.

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 4.5 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. Estimates completed using Sections 5.1.1.3 shall comply with Sections 5.1.1.4.1 through 5.1.1.4.3.

5.1.1.4.1. All estimates shall assume the standard operating conditions of Section 4.4.

5.1.1.4.2. All estimates shall be based on the Minimum Rated Features of Section 4.5.

5.1.1.4.3. 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 Price rate data published annually by the U.S. Department of Energy (DOE), Energy Information Administration (EIA).

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. Energy Rating Reference Home energy costs shall be determined by fuel type, applying the energy price rates to the individual fuel types of the Energy Rating 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 Energy Rating Reference Home.

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

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 Energy Rating 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 for electricity generation shall be used to calculate emissions.

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

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.

5.1.2.2.2.1. The Energy Rating 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 Energy Rating 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 Energy Rating 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 Energy Rating Reference Home shall be the difference between the pollution emissions of the Energy Rating 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 Energy Rating 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 Certified Rater is certified.

5.1.3.4. The date the Rating was conducted.

5.1.3.5. The name and version number of the Approved Software Rating Tool used to determine the Rating.

5.1.3.6. The following statement in no less than 10-point font, “The Energy Rating Disclosure for this home is available from the Approved Rating Provider.” At a minimum, this statement shall also include the Approved 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 5.1.4.4.

5.1.4.1. Confirmed Rating. A rating type that encompasses one individual 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 verified through inspection and testing in accordance with Section 4.5.

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

5.1.4.1.3. Confirmed Ratings shall be subjected to Quality Assurance requirements adopted by an Approved Rating Provider.

5.1.4.2. Projected Rating. A rating type that encompasses one individual Dwelling Unit and is conducted in accordance with Sections 5.1.4.2.1 through 5.1.4.2.6.

5.1.4.2.1. 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,-North, South, East and West, and the orientation resulting in the largest Energy Rating Index shall be used.

5.1.4.2.2. Projected Ratings shall use either the envelope leakage rate specified as the required performance by the construction documents, code or program requirements, the site-measured envelope leakage rate, or the air exchange rate specified for the Energy Rating Reference Home in Table 4.2.2(1).

5.1.4.2.3. Projected Ratings shall use either the Distribution System Efficiency specified as the required performance by the construction documents, code or program requirements, the site-measured Distribution System Efficiency, or the thermal Distribution System Efficiency value specified for the Energy Rating Reference Home in Table 4.2.2(1).

5.1.4.2.4. Projected Ratings shall use either the ventilation airflow specified as the required performance by the construction documents, code or program requirements, the site-measured ventilation airflow, or the ventilation airflow specified for the Energy Rating Reference unit in Table 4.2.2(1).

5.1.4.2.5. The Minimum Rated Features of Rated Homes that were determined in Sections 5.1.4.2.1 through 5.1.4.2.4 shall be entered into the Approved Software Rating Tool that generates the energy rating. The energy rating shall report the Energy Rating Index that comports with these inputs.

5.1.4.2.6. Projected Rating reports shall contain the following text in no less than 14-point font at the top of the first page of the report: “Projected Rating Based on Plans – Field Confirmation Required.”

5.1.4.3. Sampled Ratings for Detached Dwelling Units. A rating type that encompasses a set of Dwelling Units that is conducted in accordance with Sections 5.1.4.3.1 through 5.1.4.3.3. Sampled Ratings are only permitted if approved for use by the authority having jurisdiction.

5.1.4.3.1. For the set of Rated Homes, all Minimum Rated Features shall be field-verified through inspection and testing of a single Dwelling Unit in the set, or distributed across multiple Dwelling Units in the set, in accordance with Approved requirements.

5.1.4.3.2. 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 Energy Rating. The Energy Rating shall report the Energy Rating Index that comports with these inputs.

5.1.4.3.3. Sampled Ratings shall be subjected to Quality Assurance requirements adopted by an Approved Rating Provider.

5.1.4.4. Sampled Ratings for Attached Dwelling Units. A rating type that encompasses a set of Dwelling Units that is conducted in accordance with Sections 5.1.4.4.1 through 5.1.4.4.7. Sampled Ratings are only permitted if approved for use by the authority having jurisdiction.

5.1.4.4.1. Selecting unit types. A Projected Rating shall be performed on each unique Dwelling Unit

5.1.4.4.1. Selecting unit types. A Projected Rating shall be performed on each unique Dwelling Unit type, in accordance with Section 5.1.4.2. Dwelling Units with the same construction type, same envelope systems, same number of Bedrooms, same number of stories within the unit, same window area (±10%), same Conditioned Floor Area (±10%, not to exceed ±100 ft2), and same ceiling height (±0.5 ft) are permitted to be the same unit type. Dwelling Units that satisfy these criteria, but differ in other criteria, are not required to be modeled as the same unit type.

5.1.4.4.2. Worst-case Configuration. For each unique Dwelling Unit type, the Threshold Specifications resulting from the Worst-Case Analysis for the Minimum Rated Features of that Dwelling Unit type shall be entered into the Approved Software Rating Tool that generates the Energy Rating. The worst-case configuration of that unit type must then be determined using the various boundary conditions, orientations, and levels within the building to determine the worst-case configuration that results in the largest Energy Rating Index for that Dwelling Unit type. The Projected Rating for each unique Dwelling Unit type must be based on this Worst-Case Analysis and configuration. This Projected Rating then applies to all Dwelling Units of that same unit type, regardless of the actual exposure, orientation, level, or features of the actual Dwelling Unit.

5.1.4.4.2.1. Exception: A Dwelling Unit type is permitted to have a subtype, if boundary conditions, orientation, or level within the building results in a change to the Energy Rating Index of the Dwelling Unit type. The additional Projected Rating for the subtype then applies to all Dwelling Units of the same type and configuration of that subtype.

5.1.4.4.3. Threshold Specifications. In each Projected Rating, values for envelope leakage rate, Distribution System Efficiency, and ventilation airflow, shall be normalized by volume or square footage and entered into the Approved Software Rating Tool that generates the Energy Rating. The Energy Rating shall report the Energy Rating Index that comports with these inputs. These values are permitted to differ by Dwelling Unit type. If applying Sampling to inspections or testing is permitted by the authority having jurisdiction, these values are the Threshold Specifications that establish the limits for Failures for each Sampled Feature. These values are permitted to be revised based upon the results of inspections or testing in accordance with Section 5.1.4.4.5.

5.1.4.4.4. Verification. All Minimum Rated Features for each unit shall be verified through inspection and testing, in accordance with Section 4.5.

5.1.4.4.4.1. Exception: If applying Sampling to inspections or testing is permitted by the authority having jurisdiction, each instance of each Sampled Feature is not required to be directly verified. For the set of Attached Dwelling Units, all Minimum Rated Features shall be field-verified through inspection and testing of a single Dwelling Unit in the set, or distributed across multiple Dwelling Units in the set, in accordance with Approved requirements.

5.1.4.4.5. Application of Verification. Once all units in the Sampled Project have been verified, a Sampled Rating for each Dwelling Unit is created using the Projected Rating for that Dwelling Unit type and updating the Threshold Specifications of the Minimum Rated Features to reflect the poorest performance for each Minimum Rated Feature that has been verified through inspections and testing in that Dwelling Unit. The final Energy Rating for this Dwelling Unit shall report the Energy Rating Index that comports with these inputs.

5.1.4.4.5.1. Exception: If applying Sampling to inspections or testing is permitted by the authority having jurisdiction, once verification is complete, the Threshold Specifications of the Minimum Rated Features in each Projected Rating must be updated in the Approved Software Rating Tool that generates the Energy Rating to reflect the worst performance values of each Sampled Feature that has been verified through inspections or testing. The final Energy Rating for each Dwelling Unit type shall report the Energy Rating Index that comports with these inputs.

5.1.4.4.5.1.1. If any Failures occur for Minimum Rated Features, only the final performance is used when determining the worst performance value for that Minimum Rated Feature.

5.1.4.4.5.1.2. Every Dwelling Unit in the Sampled Project is represented by one of the Projected

5.1.4.4.5.1.2. Every Dwelling Unit in the Sampled Project is represented by one of the Projected Ratings performed. A Sampled Rating for each unit is created using the final energy rating for that unit type and shall be assigned the same Energy Rating Index as determined by the final rating for that unit type.

5.1.4.4.6. Labeling. Every unit in the Sampled Project shall be provided with a label in accordance with Section 5.3, which shall additionally contain one of the following statements as applicable:

5.1.4.4.6.1. "This unit has not been fully inspected or tested and has received a Sampled Rating in accordance with Section 5.1.4.4 of ANSI Standard 301."

5.1.4.4.6.2. "This unit has been fully inspected and tested and has received a Confirmed Rating in accordance with Section 5.1.4.1 of ANSI Standard 301."

5.1.4.4.7. Quality Assurance. Sampled Ratings shall be subjected to Quality Assurance requirements adopted by an Approved Rating Provider.

5.1.5. Average Dwelling Unit Energy Rating Index. A single Energy Rating Index for a building with multiple units shall not be calculated by performing an Energy Rating on that building. If a single Energy Rating Index is needed to represent the residential portions of a building or a group of multiple Detached Dwelling Units for code compliance or other programmatic reason, that substitute Energy Rating Index must be calculated using an average of the Energy Rating Index values from all the individual Dwelling Units in the building or group. A Confirmed or Sampled Rating for each Dwelling Unit in the building or group shall be performed prior to this calculation.

5.2. Innovative Design Requests.

5.2.1. Petition. Approved Rating Providers can petition for adjustment to the Energy Rating Index for a Rated Home with features or technologies not addressed by Approved Software Rating Tools or this Standard. Innovative Design Requests (IDRs) shall be submitted to an Approved IDR authority and 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 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 or describe the modeling approach used.

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

5.2.2. Approval. IDRs shall be approved on a case by case basis. The Approved IDR review authority shall accept or reject the IDR as submitted or request additional information. The Approved IDR review authority shall assign a unique identifier to each IDR and maintain a database of IDRs. If the IDR is approved, the Approved Rating Provider is authorized to issue a supplemental report that adjusts the Energy Rating Index as approved.

5.3. Labeling. 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. Energy Rating Index 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 5.1.2.1.1

5.3.5. Name and address of the Approved Rating Provider

5.3.6. Date of the Energy Rating

6. Normative References.

ACCA, "Manual B Balancing and Testing Air and Hydronic Systems", Air Conditioning Contractors of America, Arlington, VA.

ACCA, "Manual D Residential Duct Systems", [ANSI/ACCA 1 Manual D-2016], Air Conditioning Contractors of America, Arlington, VA.

ACCA, "Manual J Residential Load Calculation," 8th Edition, [ANSI/ACCA 2 Manual J-2016]. Air Conditioning Contractors of America, Arlington, VA.

ACCA, "Manual S Residential Heating and Cooling Equipment Selection.", 2nd Edition, [ANSI/ACCA 3 Manual S-2014]. Air Conditioning Contractors of America, Arlington, VA.

ASHRAE *Handbook of Fundamentals*, ~~2013~~2017. American Society of Heating Refrigerating and Air Conditioning Engineers, Atlanta, GA.

ANSI/ASHRAE 62.2-2016, "Ventilation and Acceptable Indoor Air Quality in Low Rise Buildings." American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA, 2016.

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

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

~~ANSI/ASHRAE 152-2004, "Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems." American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.~~

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Normative Appendix A

INSPECTION PROCEDURES FOR INSULATION GRADING AND ASSESSMENT

Editorial Note: Appendix A is under development in a separate amendment proceeding as Addendum F to Standard ANSI/RESNET/ICC 301-2014.

Normative Appendix B

INSPECTION PROCEDURES FOR MINIMUM RATED FEATURES

Editorial Note: Appendix B is under development in a separate amendment proceeding as Addendum N to Standard ANSI/RESNET/ICC 301-2014.

Annex X – ECM Guidelines (Informative)

General Guidelines for Determining Energy Conservation Measure (ECM) Service Lifetimes and Maintenance Fractions

	RESNET Energy Rating 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

Replacement	40	20	25	15-30	15-40
Window Film or Tint	15	10		10	10-15
Window Solar Screens	15	10			10-15

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