ANSI/RESNET/ICC 301-2022

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

February 3, 2022
Republished September 12, 2023
With Annexes Addenda A and B

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

International Code Council
500 New Jersey Avenue, NW, 6th Floor
Washington, D.C. 20001
www.iccsafe.org

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. The second edition of the standard was ANSI/RESNET/ICC 301-2019 Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index. The 2019 edition expanded the scope of the standard to include Dwelling Units and Sleeping Units in multi-family buildings of all heights and added normative appendices on inspections for grading insulation installation and inspections for minimum rated features used in determine the Energy Rating Index. This third edition, ANSI/RESNET/ICC 301-2022 Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index, Republished April 1, 2022, includes revisions approved in the triennial update proceeding and the addenda to the 2019 edition of the Standard that established criteria for consideration of HVAC systems installation quality in home energy ratings and established a rating index for home energy use related carbon dioxide emissions.

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

Forward (Informative) 2
1. Purpose 3
2. Scope 3
3. Definitions 4
4. Energy Rating Calculation Procedures 23
   4.1 Determining the Energy Rating Index 23
   4.2 Energy Reference Home and Rated Home Configuration 25
   4.3 Index Adjustment Factor (IAF) 77
   4.4 Operating Condition Assumptions 81
   4.5 Minimum Rated Features 88
5. Existing Home Retrofit Savings 98
   5.1 Baseline Existing Home 98
   5.2 Improved Home 99
   5.3 Standard Operating Conditions 99
   5.4 Energy Savings Calculations 101
6. Economic Cost Effectiveness 101
   6.1 Calculation of Ratio Parameters 102
   6.2 Standard Economic Inputs 104
7. Certification and Labeling 106
   7.1 Rating Requirements 106
   7.2 Innovative Design Requests 115
   7.3 Labeling 116
8. CO_2 Rating Index 116
9. Normative References 118
10. Informative References 120

Normative Appendix A, Inspection Procedures for Insulation Grading and Assessment A-1
Normative Appendix B, Inspection Procedures for Minimum Rated Features B-1
Annex X, ECM Guidelines (Informative)

Included Addenda:
Addendum A, Renewable Energy Certificates
Addendum B, CO_2e Index

ANSI/RESNET/ICC 301-2022

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

Foreword (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 0 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 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.

The first major Update of the Standard was the 2019 edition which changed the title and scope to cover Dwelling Units and Sleeping Units in buildings of any height. The terminology of the title and scope were revised for consistency with the International Code Council model building codes.

This is the third edition of the Standard and was developed on the three year cycle RESNET adopted for its ANS. It is designated BSR/RESNET/ICC 301-202x.

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, except hotels and motels.[1] 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.

This standard identifies the metrics, tolerances, procedures, calculations and the required documentation to: (1) Calculate the standard energy use of Dwelling Units and Sleeping Units, (2) Determine the Energy Rating Index of Dwelling Units and Sleeping Units, (3) determine the CO_2 Index of Dwelling Units and Sleeping Units, (4) Define the minimum rated features of Dwelling Units and Sleeping Units, (5) Calculate the retrofit savings for existing Dwelling Units and Sleeping Units, (6) Calculate the cost effectiveness of energy saving improvements to Dwelling Units and Sleeping Units, (7) Label the certified energy and CO_2 performance of Dwelling Units and Sleeping Units.

[1] (Normative Note) The terms "Dwelling Unit" and "Sleeping Unit" are interchangeable with the term "home" throughout this Standard, except where specifically noted.

3. Definitions. The following terms and acronyms have specific meanings as used in this Standard.[2] 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 that the context implies.

3.2. Definitions.

Air Conditioner – A vapor-compression refrigeration device that transfers heat from a location being cooled to another location using the physical properties of an evaporating and condensing fluid known as a refrigerant.

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 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 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.

[2] (Informative Note) When used in this Standard, the first letter of each word is capitalized to indicate that the term is defined in Section 3.2.

Approved Software Rating Tool [3] – 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 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.

Attic – A space volume directly below the roof assembly that is not included in the Conditioned Floor Area. Attics may be either vented or air sealed. [4]

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 0.

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 percent 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.

Bathroom – A room with at least one sink and at least one toilet.

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.[5] For all other Dwelling Units, a room or space that can be used for sleeping. For all Dwelling or Sleeping Units, the number of Bedrooms shall not be less than one.

---

[3] (Informative Note) A list of software rating tools meeting the requirements of RESNET Publication No. 002-2017 and Approved by RESNET is online at http://www.resnet.us/professional/programs/energy_rating_software.
[4] (Normative Note) Conditioned Space Volume that is intended for human activities, including but not limited to those for living, sleeping, dining, or cooking as well as toilets, closets, halls, utility areas and above the main Dwelling Unit, (for example a 'Cape Cod' home), is not considered attic space and shall be included in the Conditioned Floor Area.
[5] (Informative Note) A "den," "library," "home office," or other similar rooms with a closet, Egress Window and doorway to the main body of the Dwelling Unit as well as 70 square feet of floor area or greater are considered a Bedroom. However, living rooms, foyers and other rooms not intended for sleeping are not. The number of rooms identified as Bedrooms is used to determine the number of occupants.

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

Boiler – A space-heating appliance in which liquid is heated by burning fuel or converting electrical energy.

Blower Fan – The fan inside the equipment of a Forced-Air HVAC System that forces the heated and/or cooled air to be distributed within a Dwelling Unit.

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.

Condensing Temperature – The refrigerant Saturation Temperature measured at the service valve at the condenser coil entrance.

Condensing Temperature Over Ambient (CTOA) – A constant value that represents the difference between the Condensing Temperature and the outdoor air used to cool the refrigerant in the condenser coil.

Conditioned Floor Area (CFA)[6] – The floor area of the Conditioned Space Volume within a building or Dwelling Unit, not including the floor area of Attics or crawlspaces, and basements below air sealed and insulated floors. The following specific spaces are addressed to ensure consistent application of this definition:

- The CFA shall include the floor area of the full width of a wall assembly that is within the Conditioned Space Volume.

[6] (Informative Note) Informative Annex A of Standard ANSI/RESNET/ICC 380 contains a table that summarizes parts of a Dwelling Unit that are included in Conditioned Floor Area.

Exception: If the subject Dwelling Unit shares a wall assembly[7] with another Dwelling Unit, then the CFA of the subject Dwelling Unit shall extend to the midpoint of that shared wall assembly.

- The CFA shall include the floor area of a basement only if it is contiguous with and dedicated[8] to the subject Dwelling Unit and 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 judgment of the party conducting evaluations, are capable of maintaining space conditions at 78°F (26°C) for cooling and 68°F (20°C) for heating.
- The CFA shall exclude the floor area of a garage even when it is conditioned.
- The CFA shall exclude the floor area of a thermally isolated sunroom.
- The CFA shall exclude the floor area of an Attic even when it is Conditioned Space Volume[9].
- The CFA shall exclude the floor area of a crawlspace even when it is Conditioned Space Volume.

Conditioned Space Volume (CSV)[10] – The volume within a Dwelling Unit serviced by a space heating or cooling system designed to maintain space conditions at 78°F for cooling and 68°F 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 subject Dwelling Unit, then the CSV shall include the volume of the full depth of the floor assembly. Otherwise, the volume of the full depth of the floor assembly shall be excluded.

  Exception: The wall height used to determine the volume shall extend from the finished floor to the bottom surface of the floor decking above the Rated Dwelling Unit for all floors other than the top floor. For Dwelling Units on the top floor, this dimension shall extend from the top surface of the finished floor to the interior surface of the.
- 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 subject Dwelling Unit, CSV shall

[7] (Informative Note) For example, a common or demising wall.
[8] (Informative Note) That is, it does not span multiple Dwelling Units undivided.
[9] (Informative Note) Conditioned Space Volume that is intended for human activities (e.g., for living, sleeping, dining, or cooking; as well as toilets, closets, halls, utility areas, and laundry areas) and above the main Dwelling Unit, such as in a 'Cape Cod' home, is not considered Attic space and can be included in the Conditioned Floor Area.
[10] (Informative Note) Informative Annex A of Standard ANSI/RESNET/ICC 380 contains a table that summarizes parts of a Dwelling Unit that are included in Conditioned Space Volume.

include the volume of the full width of the wall assembly. Otherwise, the volume of the full width of the wall assembly shall be excluded.

Exception: If the subject Dwelling Unit shares a wall assembly[11] with another Dwelling Unit, then the CSV of the subject Dwelling Unit shall include half the volume of the full width of that shared wall assembly.

- The CSV shall exclude the volume of a garage, even when it is conditioned.
- The CSV shall exclude the volume of a thermally isolated sunroom.
- The CSV shall include the volume of an Attic, crawlspace, or a basement only if it is contiguous with and dedicated[12] to the subject 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 judgment of the party conducting evaluations, are capable of maintaining space conditions at 78°F (26°C) for cooling and 68°F (20°C) for heating.
- The CSV shall include the volume of an adjacent mechanical closet, regardless of access location, only if it is contiguous with and dedicated[12] to the subject Dwelling Unit, only includes equipment serving the subject 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 judgment of the party conducting evaluations, are capable of maintaining space conditions at 78°F (26°C) for cooling and 68°F (20°C) for heating.

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.

Cooling Load, Sensible – The quantity of sensible heat that must be removed from the Dwelling Unit or building to keep the space temperature at a specified thermostat setting. The sensible cooling load is independent of the distribution system(s) used to remove heat from the spaces.

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.

[11] (Informative Note) For example, a common or demising wall.
[12] (Informative Note) That is, it does not span multiple Dwelling Units undivided.

Design Temperature Difference (DTD) – A constant value that represents the difference between the evaporator coil refrigerant's Saturation Temperature and the return air dry bulb temperature within normal operating load conditions.

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

Deviation **-** shall mean the measured fractional change from a design condition whereby the measured value minus the design value is divided by the design value to yield the fractional change.

Distribution System Efficiency (DSE)[13] – 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.[14]

Drain Water Heat Recovery (DWHR) Unit – 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.

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, operating continuously or through a programmed intermittent schedule, consisting of powered Ventilation equipment,[15] related mechanical components,[16] and automated control devices[17] that provides Dwelling Unit Ventilation at a known or measured airflow rate.

Egress Window – An operable window that provides for a means of escape and access for rescue in the event of an emergency and for new construction, with the following attributes:

- Has a sill height of not more than 44 inches above the floor; and,
- Has a minimum net clear opening of 5.7 sq. ft.; and,
- Has a minimum net clear opening height of 24 in.; and,
- Has a minimum net clear opening width of 20 in.; and,

---

[13] (Informative Note) DSE is not included in manufacturer's equipment performance ratings for heating and cooling equipment.
[14] (Informative Note) Such as energy losses associated with heat transfer across duct or piping walls and air leakage to or from forced air distribution systems.
[15] (Informative Note) Such as motor-driven fans and blowers.
[16] (Informative Note) Such as ducts, inlets, dampers, or filters.
[17] (Normative Note) A switch or thermostat setting, which enables the occupant to turn a system on and off, is not considered automated, continuous, nor programmed. The presence of a ventilation override control is permitted, if the override control is labeled with text or an icon that clearly indicate its function is to turn off the ventilation system.

- Is operational from the inside of the room without the use of keys, tools or special knowledge.

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 performance of a Rated Home as compared with the energy performance of the Energy Rating Reference Home and where an Index value of 100 represents the energy performance 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 performance 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 – Skylights, roof windows, vertical windows (fixed or moveable). opaque doors, glazed doors, glazed block and combination opaque/glazed doors. Fenestration includes products with glass and non- glass glazing materials.

First Hour Rating (FHR) – The volume of hot water in gallons that a storage water heater can supply within an hour beginning with the water heater fully heated.

Forced-Air HVAC System – A type of HVAC System that incorporates a Blower Fan to move conditioned air.

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.

Furnace – A space-heating appliance in which air is heated by burning fuel or converting electrical energy.

Glazing – Sunlight-transmitting Fenestrations that enclose Conditioned Space Volume, including the area of sash, curbing or other framing elements.

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.[18]

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.[19]

[18] (Informative Note) Example: a wall

[19] (Informative Note) Most commonly, Heat Pumps draw heat from the air or from the ground moving the heat from a low temperature heat source to a higher temperature heat sink.

Heating Load – The quantity of sensible heat that must be added to the Dwelling Unit or building to keep the space temperature at a specified thermostat setting. The heating load is independent of the distribution system(s) used to add heat to the spaces.

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

Hot Water Load – The quantity of heat that must be added to mains water to supply a given quantity of hot water at a given temperature. The hot water load includes the distribution system losses, but is independent of any hot water tank heat losses.

HVAC System – Cooling-only, heating-only, or combined cooling-heating equipment, including any supply and/or return distribution systems.

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 two stories and three Bedrooms with Conditioned Floor Area of 2,400 square feet 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[20] – The sum of the Conditioned Space Volume of the subject Dwelling Unit, plus the Conditioned Space Volume and Unconditioned Space Volume of the following adjacent spaces if included[21] during the airtightness measurement of the enclosure: Attics, crawlspaces and the full depth of their floor assemblies above, basements and the full depth of their floor assemblies above, and adjacent mechanical closets and the full width of their wall assemblies between them and the subject Dwelling Unit.

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.

[20](Informative Note) Informative Annex A of Standard ANSI/RESNET/ICC 380 contains a table that summarizes parts of a Dwelling Unit that are included in Infiltration Volume.
[21] (Informative Note) Sections 4.2.4, 4.2.5, 4.2.6 and 4.2.7 of Standard ANSI/RESNET/ICC 380 define whether these adjacent spaces are to be included in Infiltration Volume.

Insulated Sheathing – An insulating board with a core material having a minimum R-Value of R-2.

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).

Load, Sensible – The quantity of heat added to or removed from a Dwelling Unit or building to satisfy specific levels of service.[22]

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.[23] For modeling purposes, the temperature of this space shall be the average of conditioned space and outside temperatures but shall be no lower than 50°F.

National Appliance Energy Conservation Act (NAECA) – Legislation by the United States Congress that regulates energy consumption of specific household appliances in the United

[22] (Informative Note) Examples are: heat added or removed to keep a space temperature at a specified thermostat setting; heat added to supply a given quantity of hot water at a given temperature, and; heat added to a space by miscellaneous appliances.
[23] (Informative Note) Such as stairwells, elevator shafts, and refuse closets.

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.

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-percent 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[24] 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, excluding electricity produced on-site that is purchased from a 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,[25] utility rooms,[26] home offices, and all outdoor fixtures

[24] (Informative Note) Projected Ratings are commonly generated prior to the construction of a new building or prior to the implementation of energy-efficiency improvements to an existing building.
[25] (Normative Note) Garages shall include an attached garage or carport if the space is not shared with other Dwelling Units.
[26] (Normative Note) Utility rooms shall include rooms used for laundry and rooms used as workshops.

mounted on the exterior of the Rated Home or on a pole. This excludes plug-in lamps, closets,[27] 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.[28]

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 ($hr \cdot ft^{2} \cdot {}^{o}F/Btu$).

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.

---

[27] (Normative Note) Closets shall include pantries, linen closets, clothes closets, closets with mechanical equipment, and storage closets inside or outside of the Dwelling Unit.
[28] (Normative Note) The definition of Residential Building corresponds to the IECC definition of Residential Building. The Occupancy Groups R-2, R-3 and R-4 are as established by the *International Building Code*.

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

Sampling – A process whereby fewer than 100 percent of the Dwelling Units are inspected, tested, or modeled to demonstrate compliance with a set of Threshold Specifications.

Saturation Temperature – The temperature at which the refrigerant undergoes a phase change in either the condenser or evaporator coils.

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.[29]

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.

Structural Insulated Panel (SIP) – A structural sandwich panel that consists of a lightweight foam plastic core securely laminated between two thin, rigid wood structural panel facings.

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.

Thermally Isolated Sunroom: A one-story structure attached to a dwelling with a glazing area in excess of 40 percent of the gross area of the structure's exterior walls and roof, with no active space conditioning equipment located within the sunroom or serving it and is thermally isolated from the Rated Home as indicated by the presence of insulation in any shared building envelope components.

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

Threshold Specifications – A set of qualification criteria that are established based on a Worst-Case Analysis of an explicit design specification.[30]

Threshold Rating - A Rating accomplished using Threshold Specifications to determine the Energy Rating Index where verification of all Minimum Rated Features is accomplished through field inspections and testing conducted on every home.

Therm – An energy unit equal to 100,000 British Thermal Units (Btu). It is 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 ($Btu/h \cdot ft^{2} \cdot {}^{o}F$) [$W/m^{2} \cdot K$].

Unconditioned Space Volume[31] **–** 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 for inclusion in Unconditioned Space Volume:

- If either one or both of the volumes above and below a floor assembly is Unconditioned Space Volume, then the volume of the full depth 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 full width of the wall assembly shall be included.

  Exception: If the volume of one of the spaces horizontally adjacent to a wall assembly is a Dwelling Unit other than the subject Dwelling Unit, then the volume of the full width of that wall assembly shall be evenly divided between both adjacent Dwelling Units.
- The volume of an attached garage shall be included, even when it is conditioned.
- The volume of a thermally isolated sunroom shall be included.
- The volume of an Attic, a crawlspace, or a basement shall be included unless it meets the definition of Conditioned Space Volume.

---

[30] (Informative Note) Such as the ENERGY STAR® Reference Design adopted by the U.S. Environmental Protection Agency.

[31] (Informative Note) Informative Annex A of Standard ANSI/RESNET/ICC 380 contains a table that summarizes parts of a Dwelling Unit that are included in Unconditioned Space Volume.

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

Unitary – One or more factory-made assemblies which normally may include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function. The equipment can be ducted or ductless; it can be a split-system or single package.

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 ± 5°F for cooling and 68°F ± 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. For modeling purposes, the temperature of this space shall be the average of conditioned space and outside temperatures but shall be no lower than 68°F.

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).[32]

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.

[32] (Informative Note) The large outdoor units typically serve multiple Dwelling Units; indoor units can be ducted units, non-ducted units, or a mix of both.

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

ASNT – American Society for Nondestructive Testing

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

FHR – First Hour Rating

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*

kWh – Kilowatt-Hour

MELs – Miscellaneous Energy Loads

MEPR – Manufacturer's Equipment Performance Rating

NAECA – National Appliance Energy Conservation Act

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) **(Equation 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) **(Equation 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[a] 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[a] water heating	1.1877	1.0130

a. 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.

$$\textbf{Energy Rating Index} = PEfrac * [TnML / (TRL * IAF_{RH})] * 100 \quad \textbf{(Equation 4.1-2)}$$

where:

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

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

IAF_{RH} = Index Adjustment Factor of Rated Home in accordance with Equation 4.3-2.

and where:

EC_{LA} = The Rated Home energy consumption for lighting, appliances and MELs as defined by Section 4.2.2.7.2, converted to MBtu/y, where MBtu/y = (kWh/y)/293 or (Therms/y)/10, as appropriate.

REC_{LA} = The Reference Home energy consumption for lighting, appliances and MELs as defined by Section 4.2.2.7.1, converted to MBtu/y, where MBtu/y = (kWh/y)/293 or (Therms/y)/10, as appropriate.

EC_{VENT} = The Rated Home energy consumption for Dwelling Unit Mechanical Ventilation System fans, converted to MBtu/y, where MBtu/y = (kWh/y)/293.

REC_{VENT} = The Reference Home energy consumption for Dwelling Unit Mechanical Ventilation System fans, converted to MBtu/y, where MBtu/y = (kWh/y)/293.

EC_{DH} = The Rated Home energy consumption for dehumidification, converted to MBtu/y, where MBtu/y = (kWh/y)/293.

REC_{DH} = The Reference Home energy consumption for dehumidification, converted to MBtu/y, where MBtu/y = (kWh/y)/293.

and where:

PEfrac = (TEU - OPP) / TEU

TEU = Total energy use of the Rated Home including all rated and nonrated 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 4.2.2.8 of this Standard.

$$\mathbf{kWh_{eq} = (Btu_{fossil} * 0.40) / 3412} \qquad \textbf{(Equation 4.1-3)}$$

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 in the Approved Software Rating Tool using identical methods and techniques.

4.2.2. Residence Specifications. The Energy Rating Reference Home and Rated Home shall be configured and analyzed in the Approved Software Rating Tool 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 separating Conditioned Space Volume from outdoor environment or Unconditioned Space Volume	Type: wood frame Gross Area: same as Rated Home U-Factor: from Table 4.2.2(2) Solar Absorptance = 0.75	Same as Rated Home 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

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

Building Component	Energy Rating Reference Home	Rated Home
	Emittance = 0.90	for wall surface in accordance with ASTM C1549 or ASTM E903 using the ASTM G197 air-mass 1.5 sun-facing global vertical solar spectral irradiance for the measurement of Solar Reflectance.[33] The Solar Absorptance value is obtained by subtracting the measured Solar Reflectance value from the number one (Solar Absorptance = 1 – Solar Reflectance) Same as Rated Home
Above-grade walls separating Conditioned Space Volume from Unrated Heated Space, Multifamily Buffer Boundary, or Non-Freezing Space	Type: wood frame Gross Area: same as Rated Home U-Factor: 0.292 for IECC Climate Zones 1&2, 0.089 for IECC Climate Zones 3-8. Solar Absorptance = 0.75 Emittance = 0.90	Same as Rated Home 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 wall surface in accordance with ANSI/CRRC S100. Same as Rated Home
Conditioned basement walls	Type: same as Rated Home Gross Area: same as Rated Home R-Value: 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	Type: wood frame Gross Area: same as Rated Home	Same as Rated Home Same as Rated Home

[33] (Normative Note) Solar Reflectance is permitted to be measured in accordance with the CRRC-1 Product Rating Program Manual Appendix 8 "Standard Test Method for Determining the Directional-Hemispherical Solar Reflectance of Materials Using a Directional-Hemispherical Portable Reflectometer" with the ASTM G197 air-mass 1.5 sun-facing global vertical solar spectral irradiance.

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

Building Component	Energy Rating Reference Home	Rated Home
Volume, Non-Freezing Space, Unrated Heated Space, or Multifamily Buffer Boundary	U-Factor: from Table 4.2.2(2)	Same as Rated Home
Floors over 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 above Conditioned Space Volume and below an Attic, Unconditioned Space Volume, Non-Freezing Space, Unrated Heated Space, or Multifamily Buffer Boundary	Type: wood frame Gross Area: same as Rated Home ceiling area 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(5) shall be used to determine Solar Absorptance, except where test data are provided for roof surface in accordance with ANSI/CRRC S100 for the measurement of Solar Reflectance. The Solar Absorptance value is obtained by subtracting the measured Solar Reflectance value from the number one (Solar Absorptance = 1 – Solar Reflectance). Emittance values provided by the roofing manufacturer in accordance with ANSI/CRRC S100 shall be used when available. In cases where the appropriate

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

Building Component	Energy Rating Reference Home	Rated Home
		data are not known, same as the Reference Home.
Attics	Type: vented with aperture = 1ft^2 per 300 ft^2 ceiling area Attic roof assemblies shall be uninsulated, while the ceiling below the Attic shall be insulated according to Table 4.2.2(2)	Same as Rated Home 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." [a] 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 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; 20 ft^2 for all others Orientation: For exterior doors: North in the northern hemisphere and South in the southern hemisphere For all other doors, in adiabatic wall	Same as Rated Home Same as Rated Home

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

Building Component	Energy Rating Reference Home	Rated Home
	U-Factor: same as Opaque Door from Table 4.2.2(2)	Same as Rated Home
Glazing[b]	Total area[c] =18% of CFA	Same as Rated Home
	Orientation: equally distributed to four (4) cardinal compass orientations (N, E, S, & W)	Same as Rated Home
	U-Factor: from Table 4.2.2(2)	Same as Rated Home
	SHGC: from Table 4.2.2(2)	Same as Rated Home
	Interior shade coefficient: Summer = 0.70 Winter = 0.85	Same as Energy Rating Reference Home[d]
	External shading: none	Same as Rated Home[e]
Skylights	None	Same as Rated Home
Thermally isolated sunrooms	None	Same as Rated Home
Air exchange rate	Specific Leakage Area (SLA)[f] = 0.00036 assuming no energy recovery, supplemented as necessary with balanced mechanical ventilation to achieve the required Dwelling Unit total air exchange rate (Qtot).[g, h]	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}[i] 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

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

Building Component	Energy Rating Reference Home	Rated Home
		shall be modeled as the Infiltration rate. For residences without Dwelling Unit Mechanical Ventilation Systems, or without measured airflow, or where A_{ext}[i] < 0.5 and the Mechanical Ventilation System is solely an Exhaust System, the Infiltration rate[j] 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[j] as determined above, in combination[h] with the time-averaged Dwelling Unit Mechanical Ventilation System rate,[g, k] which shall be the value measured in accordance with Standard ANSI/RESNET/ICC 380. To ensure that the total air exchange rate is no less than Qtot = 0.03 x CFA + 7.5 x (Nbr+1) cfm, the Dwelling Unit Mechanical Ventilation System runtime operation shall first be increased, if possible, followed by increasing the airflow rate as needed.
Dwelling Unit Mechanical Ventilation System fan power	None, except where a mechanical Ventilation system is installed in the Rated Home, in which case: Where Rated Home does not have energy recovery: 0.35 W/cfm * fanCFM_sup + 0.35 W/cfm * fanCFM_exh	Same as Rated Home[m, n, zz] except when the Dwelling Unit Mechanical Ventilation System airflow rate has been increased to meet the total air exchange rate, in which case the fan power shall be

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

Building Component	Energy Rating Reference Home	Rated Home
	Where Rated Home has energy recovery: 0.50 W/cfm * fanCFM_sup + 0.50 W/cfm * fanCFM_exh And where fanCFM_sup and fanCFM_exh are the respective minimum continuous supply and exhaust Dwelling Unit Mechanical Ventilation System fan flow rates[g] for the Rated Home.[l, zz]	proportionally increased to maintain the fan W/cfm.
Internal Gain	As specified by Table 4.2.2(3)	Same as Energy Rating Reference Home, except as provided by Section 4.2.2.7.2
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[o] but not integral to the building envelope or structure
Structural mass	For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air For masonry basement walls, same as Rated Home, but with insulation required by Table 4.2.2(2) located on the interior side of the walls For other walls, for ceilings, floors, and interior walls, wood frame construction	Same as Rated Home Same as Rated Home Same as Rated Home
Heating systems[p, q]	Fuel type: same as Rated Home Efficiencies: Electric: Air Source Heat Pump in accordance with Table 4.2.2(1b) Non-electric Furnaces: natural gas Furnace in accordance with Table 4.2.2(1b)	Same as Rated Home[q] Same as Rated Home

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

Building Component	Energy Rating Reference Home	Rated Home
	Non-electric Boilers: natural gas Boiler in accordance with Table 4.2.2(1b)	Same as Rated Home
	Capacity: sized in accordance with Section 4.4.3.1.	Same as Rated Home
	Installation Quality Grade of Forced-Air HVAC System with Furnace or Heat Pump: configured in accordance with Section 4.2.2.4.1 and modeled in accordance with Section 4.2.2.4.2.	Same as Rated Home except not smaller than the Rated Home heating load.[r] Same as Rated Home, configured in accordance with Section 4.2.2.4.1 and modeled in accordance with Section 4.2.2.4.2.
Cooling systems[p, s]	Fuel type: Electric	Same as Rated Home[s]
	Efficiency: in accordance with Table 4.2.2(1b)	Same as Rated Home
	Capacity: sized in accordance with Section 4.4.3.1.	Same as Rated Home except not smaller than the Rated Home sensible cooling load.[r]
	Installation Quality Grade of Forced-Air HVAC System with Air Conditioner or Heat Pump: configured in accordance with Section 4.2.2.4.1 and modeled in accordance with Section 4.2.2.4.2.	Same as Rated Home, configured in accordance with Section 4.2.2.4.1 and modeled in accordance with Section 4.2.2.4.2.
Service water heating systems[p, t, u, v]	Fuel type: same as Rated Home	Same as Rated Home[t]
	Efficiency: Electric: EF = 0.97 - (0.00132 * store gal) Fossil fuel: EF = 0.67 - (0.0019 * store gal)	Same as Rated Home Same as Rated Home
	Use (gal/day): Determined in accordance with Section 4.2.2.7.1.4	Determined in accordance with Section 4.2.2.7.2.11
	Tank temperature: 125°F	Same as Energy Rating Reference Home

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

Building Component	Energy Rating Reference Home	Rated Home
	Location: IECC Climate Zones 1-3: Attached garage if present, otherwise Conditioned Space Volume IECC Climate Zones: 4-8: Unconditioned basement if present, otherwise Conditioned Space Volume	Same as Rated 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 duct leakage to outside tests[w,x, y, z , yy] shall be conducted and documented by an Approved Tester in accordance with requirements of Standard ANSI/RESNET/ICC 380 with the air handler installed, and the energy impacts calculated with the ducts located and insulated as in the Rated Home. Forced air distribution systems duct area shall be the same as the Rated Home[aa]. For ductless distribution systems or distribution systems with the supply-side having a total length that does not exceed 10 ft., inclusive of both ductwork and building cavities used for distribution: DSE=1.00 For hydronic distribution systems: DSE=1.00
Thermostat	Type: manual Temperature setpoints: cooling temperature setpoint = 78°F;	Type: Same as Rated Home Temperature setpoints: same as the Energy Rating

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

Building Component	Energy Rating Reference Home	Rated Home
	heating temperature setpoint = 68ºF	Reference Home, except as required by Section 4.4.1
Dehumidification System	None, except where a dehumidification system is installed in the Rated Home, in which case: Type: Same type as the Rated Home Capacity: Same as Rated Home Efficacy: Integrated energy factor (liters/kWh) determined as a function of capacity in pints/day, as follows: 25.00 or less: 0.79 liters/kWh 25.01 – 35.00: 0.95 liters/kWh 35.01-54.00: 1.04 liters/kWh 54.01-74.99: 1.20 liters/kWh 75.00 or more: 1.82 liters/kWh Dehumidistat setpoint: 60% RH	Type: Same as Rated Home Capacity: Same as Rated Home[ab] Efficacy: Same as Rated Home Dehumidistat setpoint: Same as Energy Rating Reference Home

Table 4.2.2(1) Notes:

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

b. Glazing includes the area of sunlight-transmitting Fenestration assemblies in walls bounding conditioned basements.

c. 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 above-grade common wall area) / (gross above-grade thermal boundary wall area + gross above-grade 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.

d. For Fenestrations facing within 15 degrees of true south or true north, for Rated Homes in the northern and southern hemisphere respectively, 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.

e. 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.

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

g. The required supplemental Dwelling Unit Mechanical Ventilation System airflow rate (Qfan) shall be determined in accordance with the following equation

$$Q_{fan} = Q_{tot} - (Q_{inf} \times A_{ext})$$

where:

Q_{fan} = *Qfan,sup* = *Qfan,exh* = supplemental required mechanical Ventilation rate, cfm
Qfan,sup = supply fan air flow rate, cfm
Qfan,exh = exhaust fan air flow rate, cfm
Q_{tot} = total required Ventilation rate, cfm
Q_{inf} = *Infiltration*, cfm
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

and where:

Qtot = 0.03 * CFA + 7.5 * (Nbr+1)

Qinf = *NL* · wsf · CFA * Hr / 60

where:

NL = *normalized* leakage = 1000 * SLA * $(H / Hr)^{0.4}$

wsf = weather and shielding factor from ASHRAE Standard 62.2, Normative Appendix B

H = vertical distance between lowest and highest above-grade points within the pressure boundary (ft.)

Hr = reference height = 8.202 ft.

h. 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.

$$Q_i = Q_{fan,i} + Qinf,i$$

$$Q_i = Q_{fan,max,i} + \Phi (Qinf,i)^2 (Qinf,I + Qimb,i)$$

where:

Q_i = *combined* air exchange rate for the time step 'i', cfm

$Q_{fan,max,i}$ = *MAX(Qfan_sup, Qfan_exh)* for the time step 'i', cfm

$Q_{fan,sup,i}$ = supply fan air flow rate for time step 'i', cfm

$Q_{fan,exh,i}$ = exhaust fan air flow rate for time step 'i', cfm

$Q_{inf,i}$ = Infiltration airflow rate for the time step 'i', cfm calculated using Shelter Class 4

Qimb,i =*ABS(Qfan_sup - Qfan_exh)* for time step 'i', cfm

i. Reduction factor A_{ext} (used only for Attached Dwelling Units) shall be the ratio of exterior envelope surface area[34] to Compartmentalization Boundary.

j. 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.

k. 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.

[34] (Informative Note) Exterior envelope surface area includes any portion of the Compartmentalization Boundary that is not attached to garages, other Dwelling Units, Multifamily Buffer Boundary, Non-Freezing Space, Unrated Conditioned Space, or Unrated Heated Space. Exterior envelope surface area includes any remaining portion of the Compartmentalization Boundary that is adjacent to carports, ground or outdoor conditions or to crawlspaces and attics outside the Infiltration Volume.

2. Where the Dwelling Unit Mechanical Ventilation System is a Supply System or an Exhaust System, and not 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 combination of systems, the system airflows shall be analyzed separately in accordance with the previous steps.

l. 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 run time of each Ventilation system type.

m. Where Dwelling Unit Mechanical Ventilation Systems are specified but lack controls to either provide continuous or programmed operation, the system does not qualify as a Dwelling Unit Mechanical Ventilation System and the Rated Home shall be treated as a Dwelling Unit without a Dwelling Unit Mechanical Ventilation System. 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(1a) 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 Note g. of Table 4.2.2 (1), with a minimum of 15 cfm. 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. For systems that consume energy beyond what is needed to operate the ventilation fan[35], fan watts shall be the value observed either per OEM specifications or through direct measurement in the Rated Home for the highest airflow setting in ventilation-only mode.

Table 4.2.2(1a) 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	0.58
Range hoods	0.70

n. 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

[35] (Informative Note) Such as dehumidifying ventilation systems.

the rated fan power[36] of the shared system. The Rated Home Ventilation fan energy shall be calculated as the fan power of the entire system[37] 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 Note g. of Table 4.2.2 (1), with a minimum of 15 cfm, when calculating fan energy.

o. 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.[38] A thermal storage element must be in the same room as Fenestration that faces within 15 degrees of true south in the northern hemisphere or north in the southern hemisphere or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

p. For a Rated Home with multiple heating, cooling or water heating systems using different fuel types or having different efficiencies, 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(1b) 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(1b) 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

[36] (Normative Note) Fan motors rated in horsepower shall be converted to Watts by multiplying by 746 and dividing by fan motor efficiency. Where fan motor efficiency is unknown, use 0.65 for single-phase and 0.75 for 3-phase motors.
[37] (Normative Note) For Balanced Systems or combinations of Supply and Exhaust Systems, the system fan power must include all associated fans.
[38] (Informative Note) Such as enclosed water columns, rock beds, or phase change containers.

Note:

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.

q. For a Rated Home without a heating system, a gas Furnace with the efficiency provided in Table 4.2.2(1b) and DSE=0.80 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(1b) and DSE=0.80 shall be assumed for both the Energy Rating Reference Home and Rated Home.

r. 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[39] before delivery[40] 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), Note k. 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.

s. For a Rated Home without a cooling system, an electric Air Conditioner with the efficiency provided in Table 4.2.2(1b) and DSE=0.80 shall be assumed for both the Energy Rating Reference Home and the Rated Home.

t. For a Rated Home with a nonstorage-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 a Rated Home with a shared storage water heater, its tank losses shall be divided by the number of Dwelling Units served by the water heater, prorated based on the number of Bedrooms, (Nbr). 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

[39] (Informative Note) Example: a rooftop make-up air unit (MAU), dedicated outdoor air system (DOAS) or shared Energy Recovery Ventilator (ERV) with heating or cooling capability.

[40] (Normative Note) "Delivery" includes supply air ducted into the Dwelling Unit, or ducted into the Dwelling Unit's air distribution system or ducted in directly through the door undercut or other intentional opening. Where the supply airflow cannot be measured, it shall be equal to the measured exhaust airflow or fan CFM, whichever is greater.

for both the Rated and Energy Rating Reference Homes. The predominant fuel type shall be determined based on weighted space heating loads served by each fuel. Where the space heating loads served by different fuel types are equal, fossil fuel shall be used for the fuel type. 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). Where the Rated Home has multiple water heaters, the Energy Rating Reference Home shall have a 40-gallon storage-type water heater of the same fuel as the predominant fuel type used for the water heaters in the Rated Home. The predominant fuel type shall be determined based on weighted water heating loads served by each fuel. Where the water heating loads served by different fuel types are equal, fossil fuel shall be used for the fuel type.

u. 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. When UEF is obtained, the First Hour Rating (FHR) shall also be obtained. 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.

   Where a manufacturer provided or AHRI published EF or UEF is not available for the residential hot water equipment, the guidance provided in Item 1 below 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 Item 2 below shall be used to determine the effective TE and SL of the water heater.

   1. 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.
   2. For commercial water heaters, values provided in Table C404.2 "Minimum Performance of Water-Heating Equipment" in the IECC shall be used.

v. 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.

w. Alternatively, total duct leakage determined in accordance with Standard ANSI/RESNET/ICC 380, is permitted to be used within the Approved Software Rating Tool as if it were duct leakage to outside.

x. Any untested forced air distribution system is permitted to be modeled with a DSE of 0.70.

   When both of the following conditions are met and documented, duct leakage testing is also not required.

   1. At a pre-drywall stage of construction, 100 percent of the ductwork and airhandler shall be visible and visually verified to be contained inside the

Conditioned Space Volume.
2. At a final stage of construction, ductwork that is visible and the air handler shall be verified again to be contained in the Conditioned Space Volume.

To calculate the energy impacts on the Rated Home, a DSE of 0.80, shall be applied to both the heating and cooling system efficiencies.

If at a pre-drywall stage of construction, the ductwork is visually verified to be 100 percent fully ducted with no building cavities used as supply or return ducts, a DSE of 0.88 shall be applied to both the heating and cooling system efficiencies. As an alternative to the DSE = 0.88, a value of 4 cfm per 100 square feet of Conditioned Floor Area may be modeled for duct leakage to outside if the above conditions are met and no ductwork is contained within envelope assemblies adjacent to the exterior or Unconditioned Space Volumes.

y. Alternatively, for Townhouses and units in Dwellings only, when all of the following conditions are met and documented, total duct leakage testing is permitted to be conducted in lieu of duct leakage to outside testing and half of the measured total leakage shall be assigned duct leakage to outside.[41] At a final stage of construction, if visible ductwork or the air handler is observed outside the Infiltration Volume or ductwork is no longer 100 percent fully ducted, duct leakage to outside testing is required.

1. At a pre-drywall stage of construction, 100 percent of the ductwork and air handler shall be visible and visually verified to be contained inside the Infiltration Volume. At a final stage of construction, ductwork that is visible and the air handler shall be verified again to be contained in the Infiltration Volume.

2. At a pre-drywall stage of construction, the ductwork shall be visually verified to be 100 percent fully ducted, with no building cavities used as supply or return ducts.

3. At either a pre-drywall stage of construction or a final stage of construction, airtightness of the duct system shall be tested in accordance with requirements of Standard ANSI/RESNET/ICC 380 “Total Duct Leakage Test” (Section 5.4.1). The total leakage shall be less than or equal to the greater of 4 cfm per 100 square feet of Conditioned Floor Area served by the duct system being tested or 40 cfm. For duct systems with 3 or more returns, the total leakage shall be less than or equal to the greater of 6 cfm per 100 square feet of Conditioned Floor Area served by the duct system being tested or 60 cfm.

4. Airtightness of the Rated Home shall be tested in accordance with requirements of Standard ANSI/RESNET/ICC 380 and shall be less than or equal to 3 ACH50.

[41] (Informative Note) The criteria in this alternative apply only to single family detached homes, townhouses, and the individual units within two-family dwellings, such as duplexes.

z. Alternatively, for Attached Dwelling Units, excluding units in Dwellings and Townhouses, total duct leakage testing at either pre-drywall or final stage of construction is permitted to be conducted in lieu of duct leakage to outside testing.[42] Software shall calculate the energy impact using the total duct leakage results and prorating based on the percent of 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. The air handler contribution shall be a minimum of 2.5 percent 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. The sum of the duct leakage associated with duct surface area outside the Conditioned Space Volume and the air handler leakage shall not exceed the measured duct leakage from the entire duct system.

aa. When duct surface area is not directly measured or taken from detailed ACCA Manual D duct sizing take-offs, total duct area shall be estimated using the following equation:

$A_{supply} = 0.27 * CFA_{served}$

A_{return} = (if Number of Returns < 6, 0.05 * Number of Returns, 0.25 otherwise) * CFA_{served}

ab. The dehumidification system capacity used for the rating shall be the capacity that corresponds to 65 °F and 60 % relative humidity for portable dehumidifiers and 73 °F and 60 % relative humidity for whole-home dehumidifiers.

yy. When the air distribution system leakage split between the supply and return side is not measured, the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be split equally between the supply and return side of the air distribution system with the leakage distributed evenly across the duct system.

zz. Minimum continuous mechanical ventilation system requirements for the Rated Home shall be equal to Qfan_max, which shall be calculated as follows:

```
IF FracImbal = 0
   Qfan_max = Qtot – Qinf
ELSE
   Qfan_max = (SQRT(FracImbal^2*Qtot^2 – 4*FracImbal*Qinf^2 +
              2*FracImbal*Qinf*Qtot + Qinf^2) + FracImbal*Qtot -
              Qinf) / (2*FracImbal)
where:
   Qfan_max  = larger of Rated Home supply fan and exhaust fan air flows, cfm
   FracImbal  = ABS(Qfan_sup – Qfan_exh) / MAX (Qfan_sup, Qfan_exh)
   Qfan_sup   = Rated Home supply fan air flow, cfm
   Qfan_exh   = Rated Home exhaust fan air flow, cfm
```

[42] (Informative Note) The criteria in this alternative does not apply to single family detached homes, townhouses, or the individual units within two-family dwellings, such as duplexes.

Qtot = 0.03*CFA + 7.5*(Nbr+1)
Qinf = NL * wsf * CFA * Hr / 60
where:

NL = normalized leakage = 1000 * (ELA / CFA) * [H / Hr]^0.4 (where both ELA and CFA are in square inches)
wsf = weather and shielding factor from ASHRAE Standard 62.2, Normative Appendix B
ELA = cfm50 * 0.054863 (in2)
H = vertical distance between lowest and highest above-grade points within the pressure boundary (ft.)
Hr = reference height = 8.202 ft.

Where Qfan_max as calculated above is greater than both Qfan_sup and Qfan_exh, the Rated Home Qfan_sup and Qfan_exh shall be increased using the Rated Home FracImbal such that the larger of Qfan_sup and Qfan_exh equals Qfan_max.
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.

Table 4.2.2(2) Component Heat Transfer Characteristics for Energy Rating Reference Home[a]

Climate Zone[b]	Glazing 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 Interior Insulation R-Value[c]	Slab-on-Grade R-Value & Depth[d,e]
1	1.20	0.40	0.035	0.082	0.064	0	0
2	0.75	0.40	0.035	0.082	0.064	0	0
3	0.65	0.40	0.035	0.082	0.047	0	0
4 except Marine	0.40	0.40	0.030	0.082	0.047	10	10, 2 ft.
5 and Marine 4	0.35	0.40	0.030	0.060	0.033	10	10, 2 ft.
6	0.35	0.40	0.026	0.060	0.033	10	10, 4 ft.
7 and 8	0.35	0.40	0.026	0.057	0.033	10	10, 4 ft.

Table 4.2.2(2) Component Heat Transfer Characteristics for Energy Rating Reference Home[a]

Climate Zone[b]	Glazing and Opaque Door U-Factor	Glazed Fenestration Assembly SHGC	Ceiling U-Factor	Frame Wall U-Factor	Floor Over Unconditioned Space U-Factor	Basement Wall Interior Insulation R-Value[c]	Slab-on-Grade R-Value & Depth[d,e]

Notes:

a. U-Factor values are from 2006 IECC, Table 402.1.3 and R-Values are from 2006 IECC, Table 402.1.1.
b. Climates zones shall be as specified by the 2006 IECC.
c. For basements that are within the Conditioned Space Volume, basement wall insulation shall be continuous across the entire area of the wall.
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)]	502		143	56		16
Clothes Dryer (gas)[(b) (d)]	562		159	69		19
Dishwasher [(d)]	168		67	168		67
Clothes Washer [(d)]	135		38	15		4
General water use [(e)]	-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. 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.

(e) (Informative Note) Accounts for evaporation of roughly 2 gal of water per week from mopping, shower/tub/sink surfaces, plant watering, etc.

Table 4.2.2(4) Default Solar Absorptance for Various Wall Colors

Rated Home Wall Color	Absorptance
White	0.65
Yellow, Light Grey, or Silver	0.75
All others	0.85
Black	0.92

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

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

4.2.2.1. A framing fraction shall be designated for each segment of framed wall, floor, and ceiling assembly that separates one space type from another type or the exterior[43].

A wall segment is defined as a planar section bounded side-to-side by the wall corners and top-to-bottom by the top plate and bottom plate. A floor segment is defined as a planar section bounded by rim or band joists. A ceiling segment is defined as a planar section bounded by exterior top plates, eves, or gables. If different framing fractions are designated for different segments of the framed wall, floor, or ceiling assembly, then multiple entries are permitted to be entered into the rating software. Alternatively, the entire assembly can be modeled with the highest designated framing fraction.

For ratings where the framing is not visible at the time of the site inspection, the framing fractions shall equal the highest default framing fraction for the assembly component listed in Table 4.2.2(6).

For ratings where the framing is visible at the time of the site inspection, floor and ceiling assemblies shall use the default framing fractions for their framing spacing listed in Table 4.2.2(6). Wall assemblies shall use the default framing fractions for their framing spacing and the Standard framing type listed in Table 4.2.2(6), unless the wall assembly is a Structural Insulated Panel or a steel-framed wall, or the conditions in Section 4.2.2.1.1 or Section 4.2.2.1.2 have been met.

[43] (Informative Note) For example, that separates a Conditioned Space Volume from an Unconditioned Space Volume, Unrated Heated Space, Non-Freezing Space, a Multifamily Buffer Boundary, or the exterior.

4.2.2.1.1 The default framing fractions for the Advanced framing type are permitted to be used if the wall segment complies with all the following conditions:

4.2.2.1.1.1 Corners of cavities shall be completely filled with ≥ R-6[44] insulation.

4.2.2.1.1.2 Intersections with interior walls shall be insulated to the same R-value as the remainder of the wall assembly.[45]

4.2.2.1.1.3 Headers of frame walls shall be insulated ≥ R-3 for 2x4 framing or equivalent cavity width, and ≥ R-5 for all other assemblies[46], where the R-value requirement refers to the manufacturer's nominal insulation value[47].

4.2.2.1.1.4 The framing shall be limited at all windows & doors to one pair of king studs, plus one pair of jack studs per window opening to support the header and sill.

4.2.2.1.2 The assembly-specific framing fraction or 10%, whichever is larger, is permitted to be used if a framing plan with the design framing fraction and a professional engineer's stamp has been obtained and the framing plan has been verified to match the actual assembly in field.[48]

Table 4.2.2(6) Default Framing Fractions for Wood-Framed Assembly Components

Assembly Component	Framing Spacing (Inches On-Center)	Framing Type	Default Framing Fraction (% Area)
Wall	16	Standard	25%
	16	Advanced	19%
	24	Standard	22%
	24	Advanced	16%
	n/a	Structural Insulated Panel	10%
Floor	16	n/a	13%
	24	n/a	10%
Ceiling	16	n/a	10%

[44] (Informative Note) Examples of compliance options include standard-density insulation with alternative framing techniques, such as using three studs per corner, or high-density insulation with standard framing techniques.
[45] (Informative Note) Examples of compliance options include ladder blocking, full length 2x6 or 1x6 furring behind the first partition stud, or drywall clips.
[46] (Informative Note) For example, with 2x6 framing.
[47] (Informative Note) Examples of compliance options include continuous rigid insulation sheathing, SIP headers, other prefabricated insulated headers, or single-member or two-member headers with insulation either in between or on one side.
[48] (Informative Note) For example, a SIP wall or other engineered framed wall is permitted to use a framing fraction better than the defaults in table 4.2.2(6) if it meets the requirements of this section.

	24	n/a	7%

4.2.2.2. For roof / ceiling assemblies with eaves, any reduction in insulation thickness at the eaves shall be accounted for in accordance with section 4.2.2.2.1 through 4.2.2.2.3

4.2.2.2.1. Figures 4.2.2-1a and 4.2.2-1b provide the critical inputs, as shown for a standard eave and raised heel truss eave.[49]

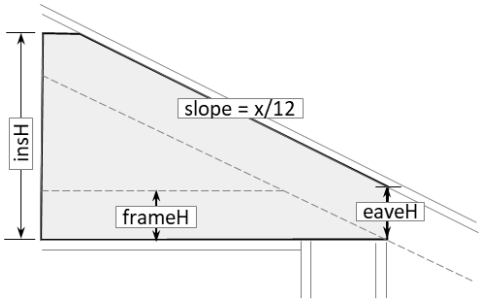


Figure 4.2.2-1a. Illustration of critical inputs for standard eave assembly

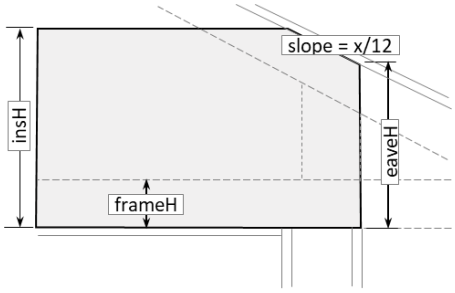


Figure 4.2.2-1b. Illustration of critical inputs for raised heel truss eave assembly

Figure 4.2.2-1 label key:

insH = height of insulation at full thickness as determined by insulation R-value and insulation resistivity (invK), where:

insH = insR/kValinvK (in)

where:

InsR = thermal resistance of ceiling insulation at full thickness ($ft^{2}\cdot^{o}F\cdot h/Btu$)

invK = thermal resistivity of ceiling insulation, resistance per inch of thickness ($ft^{2}\cdot^{o}F\cdot h/(Btu\cdot in)$)

[49] (Informative Note) Common roof/ceiling framing using roof and ceiling joists instead of trusses has the same critical inputs as shown in Figures 4.2.2-1.

slope = roof slope: inches of rise per foot of run (in/ft), *['x' in figures 4.2.2-1]*
eaveH = vertical height of insulation at exterior wall edge (in)
frameH = vertical height of framing at ceiling plane (in)

4.2.2.2.2 Where eave assemblies and the main body of the ceiling are to be modeled together, the overall ceiling insulation R-values of the given roof/ceiling assembly shall be calculated as follows:

Ric = ceilA/((ceilA-eaveA)*(1/insR) + eaveA*(1/eaveRa)) Eq. 4.2-1

where:
eaveA = MAX(eaveL* (insH-eaveH)/(slope), 0) (Eq. 4.2-1a)
where insH > eaveH
eaveRa = 1/(1/(insR-eaveH*invK)*(LN(insR/(eaveH*invK)))) (Eq. 4.2-1b)
where insH <= eaveH
eaveRa = insR (Eq. 4.2-1c)

Rif = ceilA /((ceilA-eaveA)*(1/MAX(insR - invK*frameH + 1.25*frameH, 1.25*frameH)) + eaveA*(1/MAX(eaveRa - invK*frameH + 1.25*frameH, 1.25*frameH))) (Eq. 4.2-2)

4.2.2.2.3 Where eave assemblies are to be modeled separately, the overall ceiling insulation R-values of the given roof/ceiling eave assembly shall be calculated as follows:

Ric = eaveRa (in accordance with Eq. 4.2-1b or Eq. 4.2-1c as appropriate)

Rif = eaveRa – frameH*invK + frameH*1.25 (Eq. 4.2-3)
where:
Ric = effective ceiling insulation R-value at cavity for given roof/ceiling assembly ($ft^2 \cdot {}^oF \cdot h/Btu$)
Rif = effective ceiling insulation R-value at framing for given roof/ceiling assembly ($ft^2 \cdot {}^oF \cdot h/Btu$)
ceilA = ceiling area of given roof/ceiling assembly (ft^2)
eaveA = eave area of reduced insulation thickness (ft^2)
insR = R-value of full thickness insulation ($ft^2 \cdot {}^oF \cdot h/Btu$)
eaveRa = effective R-value of reduced insulation height at given eave assembly ($ft^2 \cdot {}^oF \cdot h/Btu$)
eaveL = horizontal length of eaves across given roof/ceiling assembly (ft)

4.2.2.2.4 Default values. Where the following values are not determined and entered by the Rater, the following default values shall be used:

invK = 2.5 ($ft^2 \cdot {}^oF \cdot h/(Btu \cdot in)$)

eaveH:
truss roof/ceiling framing = 3 (in)
common roof/ceiling framing = 7 (in)

eaveL:
Hip roof = 2*(length + width) of full roof/ceiling assembly (ft)
Gable roof = 2*length of full roof/ceiling assembly (ft)

frameH:
truss roof/ceiling framing = 3.5 (in)
common roof/ceiling framing = 7.5 (in)

4.2.2.3. Insulation Inspections: All enclosure elements for the Rated Home shall have their insulation assessed in accordance with this Standard. Insulation shall be rated as Grade I, II, III or uninsulated in accordance with the on-site inspection procedures Normative Appendix A.

4.2.2.3.1. 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 Normative Appendix A or if confirmed to be present but not fully 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 nonstructural 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.

Thermographic inspection is permitted to be used to determine that an assembly is insulated and achieves a Grade II rating if the person doing the inspection is an ASNT NDT Level III or a licensed engineer or if the person doing the inspection is working under the direction of an ASNT NDT Level III or a licensed engineer. Thermographic inspection shall not be used to determine an assembly achieves a Grade I rating.

4.2.2.3.2. 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,[50] 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 percent of the insulated surface area and its measured or labeled value,

[50] (Informative Note) Such as compression and cavity fill versus continuous.

including other adjustments,[51] 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 percent of the insulated surface area and its measured or labeled value, including other adjustments,[52] 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 4.2.2.3 and combined with the cavity insulation, framing and other materials to determine the overall assembly R-Value.

(b) The base R-Value of fibrous batt 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 ACCA Manual J, 8th edition, Appendix 4.

(c) Areas of an assembly having different insulation types or R-Values (including uninsulated areas in excess of 5 percent 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.

4.2.2.4. HVAC Installation Quality Grade.

[51] (Informative Note) Such as compression and cavity fill versus continuous.
[52] (Informative Note) Such as compression and cavity fill versus continuous.

4.2.2.4.1. Configuration of Energy Rating Reference Home, Index Adjustment Design, and Rated Home.

4.2.2.4.1.1. Energy Rating Reference Home. For each Forced-Air HVAC System with an Air Conditioner, Furnace, or Heat Pump in the Energy Rating Reference Home, the installation quality of the Blower Fan airflow, Blower Fan watt draw, and (for Air Conditioners and Heat Pumps) refrigerant charge shall be designated Grade III, per Standard ANSI/RESNET/ACCA/ICC 310, and configured with the values in Table 4.5.2(5**)** [53].

4.2.2.4.1.2. Index Adjustment Design. For each Forced-Air HVAC System with an Air Conditioner, Furnace, or Heat Pump in the Index Adjustment Design, the installation quality of the Blower Fan airflow, Blower Fan watt draw, and (for Air Conditioners and Heat Pumps) refrigerant charge shall be designated Grade III, per Standard ANSI/RESNET/ACCA/ICC 310, and configured with the values in Table 4.2.2(6) [54].

Commented [RD1]: Is this change correct? There is no "Table 4.5.2(6)"

4.2.2.4.1.3. Rated Home. For each Forced-Air HVAC System with an Air Conditioner, Furnace, or Heat Pump in the Rated Home, the installation quality of the total duct leakage, Blower Fan airflow, Blower Fan watt draw, and (for Air Conditioners and Heat Pumps) refrigerant charge shall either be assessed in accordance with Standard ANSI/RESNET/ACCA/ICC 310, designated Grade I, II or III, and configured with the values in Table 4.2.2(6); or, if not assessed, shall be designated Grade III, configured with the values in Table 4.5.2(5**)**, and recorded as "Not assessed" in the rating.

Table 4.2.2(6) Air Conditioner, Furnace, and Heat Pump Installation Quality Grade Non-Default Values for Rated Home

Parameter	**Value**
Blower Fan Airflow Deviation	F_{AF} = As Rated
Blower Fan Watt Draw Efficiency	Blower Fan Efficiency = As Rated
Refrigerant Charge Deviation	F_{CHG} = 0% if Rated Grade I F_{CHG} = -25% if Rated Grade III Undercharge F_{CHG} = +25% if Rated Grade III Overcharge

4.2.2.4.2. Modeling of HVAC Installation Quality Grades. Each Forced-Air HVAC System with an Air Conditioner or Heat Pump in the Energy Rating Reference Home, Index Adjustment Design, and Rated Home shall be modeled according to Sections 4.2.2.4.2.1 and 4.2.2.4.2.2 to reflect its installation quality grade.

[53] (Informative Note) While total duct leakage must be assessed and graded in the Rated Home as a prerequisite to assessing Blower Fan airflow, no grade need be assigned for the Energy Rating Reference Home or Index Adjustment Design, because the parameter does not directly impact the energy consumption of the home.

4.2.2.4.2.1 Capacity. The gross capacity shall be modeled according to Equation 4.2-4.

$$\boldsymbol{Cap_{timestep,fault,gross} = Cap_{rated,gross} * Cap_{f(T)} * Cap_{fault}} \quad \textbf{(Eq. 4.2-4)}$$

Where:
$Cap_{timestep,fault,gross}$ is the gross capacity at the given simulation timestep
$Cap_{rated,gross}$ is the gross capacity at rated conditions [54]
$Cap_{f(T)}$ is the no-fault capacity adjustment factor for the operating temperatures at the given simulation timestep [55]
Cap_{fault} is the capacity adjustment factor for the airflow and refrigerant charge installation faults and shall be calculated according to Equation 4.2-5.

$$\boldsymbol{Cap_{fault} = \frac{CAP_{CHG}}{CAP_{AF,CHG}} * CAP_{AF}} \quad \textbf{(Eq. 4.2-5)}$$

Where:

CAP_{CHG} is a normalized capacity adjustment factor as a function of the timestep operating temperatures (T) and the refrigerant charge fault level (F_{CHG}).
For cooling mode, CAP_{CHG} is calculated according to Equation **4.2**-6 using the coefficients in Table 4.2.2.4(1).

$$\boldsymbol{CAP_{CHG} = 1 + (a1 + a2 * T_{DB_{in}} + a3 * T_{DB_{out}} + a4 * F_{CHG}) * F_{CHG}} \quad \textbf{(Eq. 4.2-6)}$$

Table 4.2.2.4(1). Capacity Charge Fault Coefficients for Cooling Mode

Coefficients	Undercharge Fault	Overcharge Fault
a1	-9.46E-01	-1.63E-01
a2	4.93E-02	1.14E-02
a3	-1.18E-03	-2.10E-04
a4	-1.15E+00	-1.40E-01

For heating mode, CAP_{CHG} is calculated according to Equation 4.2-7 using the coefficients in Table 4.2.2.4(2):

$$\boldsymbol{CAP_{CHG} = 1 + (a1 + a2 * T_{DB_{out}} + a3 * F_{CHG}) * F_{CHG}} \quad \textbf{(Eq. 4.2-7)}$$

Table 4.2.2.4(2). Capacity Charge Fault Coefficients for Heating Mode

Coefficients	Undercharge Fault	Overcharge Fault

[54] (Informative Note) Gross capacity is the net capacity plus the capacity required to remove the fan heat.
[55] (Informative Note) This factor represents the fact that operating temperatures that differ from rated conditions will result in equipment capacity that differs from rated capacity and is not a reflection of installation quality. The methodology for calculating this factor is not prescribed within this standard.

a1	-3.39E-02	-2.95E-03
a2	2.03E-02	7.38E-04
a3	-2.62E+00	-6.41E-03

$CAP_{AF,CHG}$ is a normalized capacity adjustment factor as a function of the airflow correction factor, where $CF_{AF,CHG}$ represents the adjustment to the airflow fraction due to the capacity impact of the refrigerant charge fault.
For cooling mode, $CAP_{AF,CHG}$ is calculated according to Equation 4.2-8 using the coefficients in Table 4.2.2.4(3):

$$\boldsymbol{CAP_{AF,CHG} = a1 + a2 * CF_{AF,CHG} + a3 * CF_{AF,CHG}^{2}} \quad \textbf{(Eq. 4.2-8)}$$

Table 4.2.2.4(3). Capacity Airflow Fault Coefficients for Cooling Mode

Coefficients	Airflow Fault
a1	7.19E-01
a2	4.18E-01
a3	-1.37E-01

And where $CF_{AF,CHG}$ is calculated according to Equation 4.2-9 using the coefficients in Table 4.2.2.4(1):

$$\boldsymbol{CF_{AF,CHG} = \frac{1}{1 + (a1 + a2 * 26.67 + a3 * 35.00 + a4 * F_{CHG}) * F_{CHG}}} \quad \textbf{(Eq. 4.2-9)}$$

For heating mode, $CAP_{AF,CHG}$ is calculated according to Equation 4.2-10 using the coefficients in Table 4.2.2.4(4):

$$\boldsymbol{CAP_{AF,CHG} = a1 + a2 * CF_{AF,CHG} + a3 * CF_{AF,CHG}^{2}} \quad \textbf{(Eq. 4.2-10)}$$

Table 4.2.2.4(4). Capacity Airflow Fault Coefficients for Heating Mode

Coefficients	Airflow Fault
a1	6.94E-01
a2	4.74E-01
a3	-1.68E-01

And where $CF_{AF,CHG}$ is calculated according to Equation 4.2-11 using the coefficients in Table 4.2.2.4(2):

$$\boldsymbol{CF_{AF,CHG} = \frac{1}{1 + (a1 + a2 * 8.33 + a3 * F_{CHG}) * F_{CHG}}} \quad \textbf{(Eq. 4.2-11)}$$

CAP_{AF} is a normalized capacity adjustment factor as a function of the airflow fraction, where $F_{AF,comb}$ represents the combined airflow fraction accounting for both the airflow fault level and the adjusted airflow fraction due to the capacity impact of the refrigerant charge.

For cooling mode, CAP_{AF} is calculated according to Equation 4.2-12 using the coefficients in Table 4.2.2.4(3):

$$\boldsymbol{CAP_{AF} = a1 + a2 * F_{AF,comb} + a3 * F_{AF,comb}^{2}} \quad \textbf{(Eq. 4.2-12)}$$

And where $F_{AF,comb}$ is calculated according to Equation 4.2-13 using the coefficients in Table 4.2.2.4(1):

$$\boldsymbol{F_{AF,comb} = \frac{1}{1 + (a1 + a2 * 26.67 + a3 * 35.00 + a4 * F_{CHG}) * F_{CHG}} * (1 + FAF)} \quad \textbf{(Eq. 4.2-13)}$$

For heating mode, CAP_{AF} is calculated according to Equation 4.2-14 using the coefficients in Table 4.2.2.4(4):

$$\boldsymbol{CAP_{AF} = a1 + a2 * F_{AF,comb} + a3 * F_{AF,comb}^{2}} \quad \textbf{(Eq. 4.2-14)}$$

And where $F_{AF,comb}$ is calculated according to Equation 4.2-15 using the coefficients in Table 4.2.2.4(2):

$$\boldsymbol{F_{AF,comb} = \frac{1}{1 + (a1 + a2 * 8.33 + a3 * F_{CHG}) * F_{CHG}} * (1 + FAF)} \quad \textbf{(Eq. 4.2-15)}$$

4.2.2.4.2.2. System Efficiency. The gross system efficiency shall be modeled according to Equation 4.2-16.

$$\boldsymbol{COP_{timestep,fault,gross} = COP_{rated,gross} * COP_{f(T)} * COP_{fault}} \quad \textbf{(Eq. 4.2-16)}$$

Where:
$COP_{timestep,fault,gross}$ is the gross system efficiency at the given simulation timestep
$COP_{rated,gross}$ is the gross system efficiency at rated conditions [56]
$COP_{f(T)}$ is the no-fault system efficiency adjustment factor for the operating temperatures at the given simulation timestep [57]
COP_{fault} is the system efficiency adjustment factor for the airflow and refrigerant charge installation faults and shall be calculated according to Equation 4.2-17.

$$\boldsymbol{COP_{fault} = \frac{COP_{CHG}}{COP_{AF,CHG}} * COP_{AF}} \quad \textbf{(Eq. 4.2-17)}$$

[56] (Informative Note) Gross efficiency is the gross system capacity divided by the power of the outdoor unit.
[57] (Informative Note) This factor represents the fact that operating temperatures that differ from rated conditions will result in a system efficiency that differs from the rated efficiency and is not a reflection of installation quality. The methodology for calculating this factor is not prescribed within this standard.

Where:

COP_{CHG} is a normalized system efficiency adjustment factor as a function of the timestep operating temperatures (T) and the refrigerant charge fault level (F_{CHG}). For cooling mode, COP_{CHG} is calculated according to Equation 4.2-18 using the coefficients in Table 4.2.2.4(5):

$$\boldsymbol{COP_{CHG} = CAP_{CHG} / (1 + (a1 + a2 * T_{DB_{in}} + a3 * T_{DB_{out}} + a4 * F_{CHG}) * F_{CHG})} \quad \textbf{(Eq. 4.2-18)}$$

Table 4.2.2.4(5). Capacity Charge Fault Coefficients for Cooling Mode

Coefficients	Undercharge Fault	Overcharge Fault
a1	-3.13E-01	2.19E-01
a2	1.15E-02	-5.01E-03
a3	2.66E-03	9.89E-04
a4	-1.16E-01	2.84E-01

For heating mode, COP_{CHG} is calculated according to Equation 4.2-19 using the coefficients in Table 4.2.2.4(6):

$$\boldsymbol{COP_{CHG} = CAP_{CHG} / (1 + (a1 + a2 * T_{DB_{out}} + a3 * F_{CHG}) * F_{CHG})} \quad \textbf{(Eq. 4.2-19)}$$

Table 4.2.2.4(6). Capacity Charge Fault Coefficients for Heating Mode

Coefficients	Undercharge Fault	Overcharge Fault
a1	6.16E-02	-5.94E-02
a2	4.46E-03	1.59E-02
a3	-2.60E-01	1.89E+00

$COP_{AF,CHG}$ is a normalized system efficiency adjustment factor as a function of the airflow correction factor, where $CF_{AF,CHG}$ represents the adjustment to the airflow fraction due to the capacity impact of the refrigerant charge fault.
For cooling mode, $COP_{AF,CHG}$ is calculated according to Equation 4.2-20 using the coefficients in Table 4.2.2.4(7):

$$\boldsymbol{COP_{AF,CHG} = 1/(a1 + a2 * CF_{AF,CHG} + a3 * CF_{AF,CHG}^{2})} \quad \textbf{(Eq. 4.2-20)}$$

Table 4.2.2.4(7). Capacity Airflow Fault Coefficients for Cooling Mode

Coefficients	Airflow Fault
a1	1.14E+00
a2	-1.39E-01
a3	-4.05E-03

And where $CF_{AF,CHG}$ is calculated according to Equation 4.2-21 using the coefficients in Table 4.2.2.4(1):

$$CF_{AF,CHG} = \frac{1}{1 + (a1 + a2 * 26.67 + a3 * 35.00 + a4 * F_{CHG}) * F_{CHG}} \quad \textbf{(Eq. 4.2-21)}$$

For heating mode, $COP_{AF,CHG}$ is calculated according to Equation 4.2-22 using the coefficients in Table 4.2.2.4(8):

$$COP_{AF,CHG} = 1/(a1 + a2 * CF_{AF,CHG} + a3 * CF_{AF,CHG}^{2}) \quad \textbf{(Eq. 4.2-22)}$$

Table 4.2.2.4(8). Capacity Airflow Fault Coefficients for Heating Mode

Coefficients	Airflow Fault
a1	2.19E+00
a2	-1.94E+00
a3	7.57E-01

And where $CF_{AF,CHG}$ is calculated according to Equation 4.2-23 using the coefficients in
Table 4.2.2.4(**2**):

$$CF_{AF,CHG} = \frac{1}{1 + (a1 + a2 * 8.33 + a3 * F_{CHG}) * F_{CHG}} \quad \textbf{(Eq. 4.2-23)}$$

COP_{AF} is a normalized system efficiency adjustment factor as a function of the airflow fraction, where $F_{AF,comb}$ represents the combined airflow fraction accounting for both the airflow fault level and the adjusted airflow fraction due to the capacity impact of the refrigerant charge.
For cooling mode, COP_{AF} is calculated according to Equation 4.2-24 using the coefficients in Table 4.2.2.4(7):

$$COP_{AF} = 1/(a1 + a2 * F_{AF,comb} + a3 * F_{AF,comb}^{2}) \quad \textbf{(Eq. 4.2-24)}$$

And where $F_{AF,comb}$ is calculated according to Equation 4.2-25 using the coefficients in Table 4.2.2.4(1):

$$F_{AF,comb} = \frac{1}{1+(a1+a2*26.67+a3*35.00+a4*F_{CHG})*F_{CHG}} * (1 + F_{AF}) \quad \textbf{(Eq. 4.2-25)}$$

For heating mode, COP_{AF} is calculated according to Equation 4.2-26 using the coefficients in Table 4.2.2.4(8):

$$COP_{AF} = 1/(a1 + a2 * F_{AF,comb} + a3 * F_{AF,comb}^{2}) \quad \textbf{(Eq. 4.2-26)}$$

And where $F_{AF,comb}$ is calculated according to Equation 4.2-27 using the coefficients in

Table 4.2.2.4(**2**):

$$F_{AF,comb} = \frac{1}{1+(a1+a2*8.33+a3*F_{CHG})*F_{CHG}} * (1 + F_{AF}) \quad \textbf{(Eq. 4.2-27)}$$

4.2.2.5. Renewable Energy Systems shall not be included in the Reference Home.

4.2.2.6. For non-electric Boilers, the values in Table 4.2.2.6(1) shall be used for Electric Auxiliary Energy (Eae) in the Reference Home.

Table 4.2.2.6(1) Electric Auxiliary Energy for Fossil Fuel Heating Systems

System Type	Eae
Oil Boiler	330
Gas Boiler	170

4.2.2.7. Lighting, Appliances, Miscellaneous Energy Loads (MELs), Ventilation and Service Hot Water Systems.

4.2.2.7.1. 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 4.2.2.7(1) and Table 4.2.2.7(2), as appropriate, and Equation 4.2-28:

kWh (or therms) per year = a + b*CFA + c*Nbr (Equation 4.2-28)

where:
a, *b*, and *c* are values provided in Table 4.2.2.7(1) and Table 4.2.2.7(2)
CFA = Conditioned Floor Area
Nbr = number of Bedrooms

4.2.2.7.1.1 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 4.2.2.7(1).

Table 4.2.2.7(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	398		113
Dishwasher	kWh/y	60		24
Clothes Washer	kWh/y	53.53		15.18

4.2.2.7.1.2 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 4.2.2.7(2), as applicable for each appliance.

Table 4.2.2.7(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	14.3		4.05
Clothes Dryer	kWh/y	31.5		8.93

Note:
a. Both the natural gas and the electric components shall be included in determining the Energy Rating Reference Home appliances.

4.2.2.7.1.3. 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 included in the Reference Home.

4.2.2.7.1.4. 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 4.2-29:

$$\mathbf{HWgpd = (refDWgpd + refCWgpd + F_{mix}*(refFgpd + refWgpd))} \quad \textbf{(Equation 4.2-29)}$$

where:
HWgpd = gallons per day of hot water use
refDWgpd = reference dishwasher gallons per day
= 0.7801*Nbr+1.976
refCWgpd = reference clothes washer gallons per day
= 0.6762*Nbr + 2.3847

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} = $(T_{amb,avg} + \textit{offset}) + \text{ratio} * (\Delta T_{amb,max} / 2) * \sin(0.986 * (\text{day\#} - 15 - \textit{lag}) - 90)$ (with a minimum value of 32ºF)

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[58] (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.

4.2.2.7.1.5. Ceiling Fans. Where ceiling fans are included in the Rated Home, they shall also be included in the Reference Home in accordance with the provisions of Section 4.2.2.7.2.12.

4.2.2.7.2. 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 4.2.2.7.1 through 4.2.2.7.2.12. For a Rated Home without a refrigerator, dishwasher, range/oven, clothes washer or clothes dryer, the values from Table 4.2.2.7(1) shall be assumed for both the Energy Rating Reference Home and Rated Home.

[58] (Informative Reference) For example: $T_{amb,avg,july} - T_{amb,avg,january}$

4.2.2.7.2.1. 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.

4.2.2.7.2.2. Interior Lighting. Interior lighting annual energy use in the Rated Home shall be determined in accordance with Equation 4.2-30:

$$\mathbf{kWh/y = 0.9/0.925*(455 + 0.8*CFA)*[(1 - FFII_{IL} - FFI_{IL}) + FFI_{IL}*15/60 + FFII_{IL}*15/90] + 0.1*(455 + 0.8*CFA)} \quad \textbf{(Equation 4.2-30)}$$

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, EC_{LA} shall be adjusted by ΔEC_{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 4.2.2.7.1 converted to MBtu/y, where MBtu/y = (kWh/y)/293.

For interior lighting, Internal Gains in the Rated Home shall be modified by 100 percent of the interior lighting ΔEC_{IL} converted to Btu/day as follows: $\Delta EC_{IL} * 10^6 / 365$.

4.2.2.7.2.3. Exterior Lighting. Exterior lighting annual energy use in the Rated Home shall be determined in accordance with Equation 4.2-31:

$$\mathbf{kWh/y = (100 + 0.05*CFA)*[(1 - FFI_{EL} - FFII_{EL}) + 15/60*FFI_{EL} + 15/90*FFII_{EL}]} \quad \textbf{(Equation 4.2-31)}$$

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, EC_{LA} shall be adjusted by ΔEC_{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 4.2.2.7.1, 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.

4.2.2.7.2.4. 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 4.2-32:

$$\mathbf{kWh = 100*[(1 - FFI_{GL} - FFII_{GL}) + 15/60*FFI_{GL} + 15/90*FFII_{GL}]} \quad \textbf{(Equation 4.2-32)}$$

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, EC_{LA} shall be adjusted by ΔEC_{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 4.2.2.7.1, 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.

4.2.2.7.2.5. 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 4.2.2.7.2.5(1).

Table 4.2.2.7.2.5(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 4.2.2.7.2.5(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 4.2.2.7.2.5(3)

Table 4.2.2.7.2.5(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, EC_{LA} shall be adjusted by ΔEC_{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 4.2.2.7.1, 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 percent of the refrigerator ΔEC_{FRIG} converted to Btu/day as follows: $\Delta EC_{FRIG} * 10^6 / 365$. Internal Gains shall not be modified for refrigerators located in Unconditioned Space Volume, Unrated Heated Space, Unrated Conditioned Space or outdoor environment.[59]

4.2.2.7.2.6. 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.

4.2.2.7.2.7. Range/Oven. Range/Oven (cooking) annual energy use for the Rated Home shall be determined in accordance with Equations 4.2-33a through 4.2-30c, as appropriate.

1) For electric cooking:
kWh/y = BEF * OEF * (331 + 39*Nbr) **(Equation 4.2-33a)**

2) For natural gas cooking:
Therms/y = OEF*(22.6 + 2.7*Nbr) **(Equation 4.2-33b)**
plus:
kWh/y = 22.6 + 2.7*Nbr **(Equation 4.2-33c)**

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, EC_{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 4.2.2.7.1, converted to MBtu/y, where MBtu/y = (kWh/y) / 293 or (Therms/y) / 10, whichever is applicable.

[59] (Informative Note) Example: an unconditioned garage.

For range/oven energy use, Internal Gains in the Rated Home shall be modified by 80 percent of the range/oven ΔEC_{RO} converted to Btu/day as follows: $\Delta EC_{RO} * 10^6 / 365$. Of this total amount, Internal Gains shall be apportioned as follows, depending on fuel type:

a) For electric range/ovens, 90-percent sensible Internal Gains and 10-percent latent Internal Gains

b) For gas range/ovens, 80-percent sensible Internal Gains and 20-percent latent Internal Gains.

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

4.2.2.7.2.8. Clothes Dryers. Clothes Dryer annual energy use for the Rated Home shall be determined in accordance with Equation 4.2-34 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.

CDkWh/y = (((RMC-0.04)*100)/55.5)*(8.45/CEF)*ACY **(Equation 4.2-34)**

where:

RMC = Remaining Moisture Content = (0.97 * (CAPw / IMEF) – LER/312) / ((2.0104 * CAPw + 1.4242) * 0.455) + 0.04

ACY = Annual Cycles per Year = (164+46.5*Nbr) * ((3*2.08+1.59) / (CAPw*2.08+1.59))

Nbr = Number of Bedrooms in home.

CEF = Combined Energy Factor is the clothes dryer efficiency[60] (lbs dry clothes/kWh) based on current U.S. DOE clothes dryer testing procedures. (default = 3.73 for electric dryers or 3.30 for gas dryers)

CAPw = Capacity of clothes washer (ft^3) from the manufacturer's data

IMEF = Integrated Modified Energy Factor, which has replaced MEF as the U.S. DOE Energy Factor

[60] (Informative Reference) See the CEC Appliance Efficiency Database http://www.energy.ca.gov/appliances/ or the ENERGY STAR Appliance database https://www.energystar.gov/products/appliances/clothes_dryers.

test metric for clothes washers. (default = 1.57 for top load clothes washers or 1.84 for front load clothes washers)

LER = Labeled Energy Rating of clothes washer (kWh/y) from the Energy Guide label.

For natural gas clothes dryers, annual energy use shall be determined in accordance with Equations 4.2-35a and 4.2-35b.

Therms/y = (result of Equation 4.2-31)*3412*(1-0.07) *(3.73/3.30)/100000 (Equation 4.2-35a)

kWh/y = (result of Equation 4.2-31)*0.07*(3.73/3.30) (Equation 4.2-35b)

For the purpose of adjusting the annual clothes dryer energy consumption for calculating the Rating, EC_{LA} shall be adjusted by ΔEC_{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 4.2.2.7.1, 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 4.2.2.7(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 percent of the clothes dryer ΔEC_{CD} converted to Btu/day as follows: $\Delta EC_{CD} * 10^6 / 365$. Of this total amount, 90 percent shall be apportioned to sensible Internal Gains and 10 percent 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.[61]

4.2.2.7.2.9. Dishwashers. Dishwasher annual energy use for the Rated Home shall be determined in accordance with Equation 4.2-36a and shall be based on the dishwasher located within the Rated Home, with the highest kWh/y. If no dishwasher is located within the Rated Home, a dishwasher in the nearest shared kitchen in the building shall

[61] (Informative Note) Example: an unconditioned garage.

be used only if available for daily use by the occupants of the Rated Home.

dWkWh/y = dWkWh/cyc * dWcpy **(Equation 4.2-36a)**

where:

dWkWh/y = dishwasher annual electric use excluding water heater energy use

dWkWh/cyc = [(GHWC * 0.5497/ Gas$ - LER * Elec$ * 0.02504 / Elec$) / (Elec$ * 0.5497 / Gas$ - 0.02504)] / 208

GHWC = Labeled annual cost when used with a gas water heater

Gas$ = Labeled price of gas in $/therm

LER = Labeled dishwasher Energy Rating using electric water heater in kWh/y

Elec$ = Labeled price of electricity in $/kWh

dWcpy = dishwasher cycles per year = (88.4 + 34.9*Nbr)*12/dWcap

Nbr = Number of bedrooms in Rated Home

dWcap = Dishwasher capacity where Standard = 12 and Compact = 8

And the change (Δ) in daily hot water use (GPD – gallons per day) for dishwashers shall be calculated in accordance with Equation 4.2-36b.

ΔGPD_{DW} = refDWgpd - rateDWgpd **(Equation 4.2-36b)**

where:

refDWgpd = [(88.4+34.9*Nbr)*8.16] / 365

rateDWgpd = (LER - kWh/cyc*208) * 0.02504 * dWcpy / 365

For dishwashers where an Energy Guide label is not available, dishwasher inputs from Table 4.2.2.7.2.9 shall be used.

Table 4.2.2.7.2.9 Default Dishwasher Inputs

Default Dishwasher Energy Guide Label Data				
Energy Guide Label Information	ENERGY STAR Defaults		NAECA minimum	ERI Reference
Dishwasher Size	compact	standard	standard	standard
Annual Energy kWh/y (LER)	203	270	307	467
Annual Gas Hot Water Cost ($/y)	$14.20	$22.23	$22.32	$33.12
Electricity Price ($/kWh)	$0.12	$0.12	$0.12	$0.12
Gas Price ($/therm)	$1.09	$1.09	$1.09	$1.09
Label Cycles per Year (LCY)	208	208	208	208

For the purpose of adjusting the annual dishwasher energy consumption for calculating the Rating, EC_{LA} shall be adjusted by ΔEC_{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**.2.2.7.1, 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 4.2.2.7.1.

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

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

4.2.2.7.2.10. 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 4.2-37a.

CWkWh/y = Cwappl / LCY * ACY **(Equation 4.2-37a)**

where:

Cwappl = (GHWC * gasH2O / gas$ - (LER*elec$) * elecH2O / elec$) / (elec$ * gasH2O / gas$ - elecH2O)

GHWC = Gas Hot Water Costs from Energy Guide Label

gasH2O = 0.3914 (gal/cyc) per (therm/y)

elecH2O = 0.0178 (gal/cyc) per (kWh/y)
LER = Label Energy Rating (kWh/y) from the Energy Guide Label.
elec$ = Electric Rate from Energy Guide Label. (default = $0.12 per kWh)
gas$ = Gas Rate from Energy Guide Label. (default = $1.09 per therm)
LCY = Label Cycles per Year from Energy Guide Label (default = 6 loads per week = 312)
ACY = Annual Cycles per Year.

and where:

ACY = SCY * [(3.0*2.08+1.59)/(CAPw*2.08+1.59)]

where:

SCY = (164 + Nbr*46.5).
CAPw = washer capacity in cubic feet from the Energy Guide Label

Daily hot water use shall be calculated in accordance with Equation 4.2-37b.

CWgpd = (LER – Cwappl) * elecH2O * ACY / 365
(Equation 4.2-37b)

For clothes washers where an Energy Guide label is not available, clothes washer inputs from Table 4.2.2.7.2.10 shall be used.

Table 4.2.2.7.2.10 Default Inputs for Clothes Washer Based on Year

Standard Clothes Washer Models						
	ERI Ref 2006[a]	Std 2008-2017[b]	ENERGY STAR 2006-2017[c]	Std 2018-present	ENERGY STAR 2018-present	CEE Tier II 2018[d]
Clothes Washer Inputs:						
LER [Label Energy Rating in kWh/y]=	400	380	260	284	152	125
GHWC [Cost with gas hot water in $/y]=	$27	$27	$18	$18	$12	$9
elec_price [$/kWh]=	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12
gas_price [$/therm]=	$1.09	$1.09	$1.09	$1.09	$1.09	$1.09
IMEF [ft3/(kWh/cyc)]=	1	1.21	1.63	1.57	2.06	2.92
CAPw [ft3]=	3	3.2	3.5	4.2	4.2	5.2
IWF [(gal/cyc)/ft3]=	11.4	9.5	5.2	6.5	4.3	3.2
LCY [Label Cycles per Year] =	312	312	312	312	312	312

Footnotes
a: Used for standard clothes washers between 2006 – 2007
b: Used for standard clothes washers between 2008 – 2017
c: Used for ENERGY STAR clothes washers between 2006 and 2017
d: Consortium for Energy Efficiency Tier II efficiency minimum requirements

For the purpose of adjusting the annual clothes washer energy consumption for calculating the Rating, EC_{LA} shall be adjusted by ΔEC_{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 4.2.2.7.1, 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 4.2.2.7.1.4.

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 4.2.2.7.1.

For clothes washer energy use, total Internal Gains in the Rated Home shall be modified by 30 percent of the clothes washer ΔEC_{CW} converted to Btu/day as follows: $\Delta EC_{CW} * 10^6 / 365$. Of this total amount, 90 percent shall be apportioned to sensible Internal Gains and 10 percent 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.[62]

4.2.2.7.2.11. Service Hot Water Use. Service hot water system use in gallons per day for the Rated Home shall be determined in accordance with Equation 4.2-38.

$$\mathbf{HWgpd = (DWgpd + CWgpd + F_{eff} * adjF_{mix} * (refFgpd + oWgpd + sWgpd * WD_{eff}))} \quad \textbf{(Equation 4.2-38)}$$

where:

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

[62] (Informative Note) Example: an unconditioned garage.

= ((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, and it is evident which water heater provides an appliance with hot water, 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 4.2.2.7.2.11(1).

Table 4.2.2.7.2.11(1) Hot water fixture effectiveness

Plumbing Fixture Description	**F_{eff}**
Standard-flow: showers ≤2.5 gpm and Bathroom sink faucets ≤2.2 gpm	1.00
Low-flow: all showers[63] and Bathroom sink faucets ≤2.0 gpm	0.95

$adjF_{mix} = 1 – ((T_{set} – T_{use})/ (T_{set} – WH_{in}T))$ (Equation 4.2-39)

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 4.2-42.

$WH_{in}T$ = T_{mains} for all other hot water systems.

T_{mains} = temperature of potable water supply entering the residence calculated in accordance with Section 4.2.2.7.1.4.

refFgpd = reference climate-normalized daily fixture water use calculated in accordance with Section 4.2.2.7.1.4.

$oWgpd = refWgpd * oFrac * (1-oCD_{eff})$ (Equation 4.2-40)

where:

[63] (Normative Note) A shower with multiple showerheads that operate simultaneously meets the low-flow criteria if the sum of the flow rates of all showerheads is less than or equal to 2.0 gpm.

oWgpd = daily standard operating condition waste hot water quantity.
oFrac = 0.25
= fraction of hot water waste from standard operating conditions.
oCDeff = Approved Hot Water Operational Control Device effectiveness (default = 0.0)

sWgpd = (refWgpd – refWgpd * oFrac) * pRatio * sysFactor **(Equation 4.2-41)**

where:
sWgpd = daily structural waste hot water quantity.
refWgpd = reference climate-normalized distribution system waste water use calculated in accordance with Section 4.2.2.7.1.4.
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[64] 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.

[64] (Informative Note) Pump energy associated with the shared central recirculation loops are modeled separately from this section in section 4.2.2.7.2.11.2.

for recirculation systems (entirely within the Rated Home):[65]

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 4.2.2.7.2.11(2).

Table 4.2.2.7.2.11(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 4.2.2.7.2.11(3)[43]

Table 4.2.2.7.2.11(3) Distribution system water use effectiveness

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

4.2.2.7.2.11.1. 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 4.2-42.

$$\mathbf{WH_{in}T_{adj} = Ifrac*(DWHR_{in}T - T_{mains})*DWHR_{eff}*PLC*LocF*FixF} \quad \textbf{(Equation 4.2-42)}$$

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 4.2.2.7.1.4

[65] (Normative Note) Attached Dwelling Units shall be modeled with a Standard (nonrecirculating) system, except for recirculating systems that are entirely within the Rated Home (i.e., an individual Townhouse).

$DWHR_{eff}$ = 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 4.2.2.7.2.11(1).

PLC = 1 - 0.0002*pLength = piping loss coefficient.

where:

for standard systems:

pLength = pipeL as measured accordance with Section 4.2.2.7.2.11

for recirculation systems (entirely within the Rated Home):[66]

pLength = branchL as measured in accordance with Section 4.2.2.7.2.11

LocF = a performance factor based on the installation location of the DWHR determined from Table 4.2.2.7.2.11(4).

Table 4.2.2.7.2.11(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.

4.2.2.7.2.11.2. Hot Water System Annual Energy Consumption

Service hot water energy consumption shall be calculated using Approved Software Tools. The provisions of Section 4.2.2.7.1.4, Section 4.2.2.7.2.11 and Section 4.2.2.7.2.11 shall be followed to determine appropriate inputs to the calculations.

[66] (Normative Note) Attached Dwelling Units shall be modeled with a Standard (nonrecirculating) system, except for recirculating systems that are entirely within the Rated Home (i.e., an individual Townhouse).

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 4.2-43a for recirculation systems located completely within the Dwelling Unit. The shared recirculation pump kWh/y shall be calculated using Equation 4.2-43b for shared recirculation systems serving multiple Dwelling Units. The recirculation pump kWh/y shall be pro-rated to a Dwelling Unit based on its number of Bedrooms relative to the total number of Bedrooms of all Dwelling Units served by the hot water recirculation system.

pumpkWh/y = pumpW * Efact **(Equation 4.2-43a)**

Where:

pumpW = pump power in Watts (default pumpW = 50 Watts).

Efact = factor selected from Table 4.2.2.7.2.11(5).

Table 4.2.2.7.2.11(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

$SharedHWpumpkWh/y = SHWP_{kW} * OpHrs * (N_{br}/N_{brtotdwu})$ **(Equation 4.2-43b)**

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 or temperature control].

N_{br} = number of Bedrooms in the Rated Home (rated Dwelling Unit), not less than 1.

$N_{brtotdwu}$ = total number of Bedrooms for all Dwelling Units served by the shared hot water recirculation system, not less than 1 per unit.

Results from standard hot water energy consumption data (stdECHW)[67] shall be adjusted to account for the energy delivery effectiveness of the hot water distribution system in accordance with Equation 4.2-44.

$$\mathbf{EC_{HW} = stdEC_{HW} * (E_{waste} + 128) / 160}$$ **(Equation 4.2-44)**

where E_{waste} is calculated in accordance with Equation 4.2-45.

$$\mathbf{E_{waste} = oEW_{fact} * (1\text{-}oCD_{eff}) + sEW_{fact} * pEratio}$$ **(Equation 4.2-45)**

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 4.2.2.7.2.11(6).

oCD_{eff} is in accordance with Section 4.2.2.7.2.11

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):[68]

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

[67] (Normative Note) The value for the water heater inlet temperature, $WH_{in}T$, used to determine $adjF_{mix}$ shall be the value for the water heater inlet temperature used to calculate $stdEC_{HW}$.

[68] (Normative Note) Attached Dwelling Units shall be modeled with a Standard (nonrecirculating) system, except for recirculating systems that are entirely within the Rated Home (i.e., an individual Townhouse).

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 4.2.2.7.2.11(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

4.2.2.7.2.12. 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) and 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 4.2-46.

LCFSW = (3000cfm) / (cfm/Watt as labeled at medium speed)

(Equation 4.2-46)

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-percent 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 energy consumption (EC_{LA} and REC_{LA}, as appropriate) as specified by Equation 4.1-2 in Section 4.1.2.

4.2.2.8. 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) and is used to calculate the Energy Rating Index of the Rated Home, 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

Building Component	Index Adjustment Design (IAD)
Above-grade walls separating Conditioned Space Volume from outdoor environment, Unconditioned Space Volume, Unrated Heated Space, Multifamily Buffer Boundary, or Non-Freezing Space	Type: Same as Rated Home. If more than one type, maintain same proportional coverage for each type, only wall area separating Conditioned Space Volume and the outdoor environment. U-Factor: Same as Rated Home Solar Absorptance: Same as Rated Home Emittance: Same as Rated Home
Ceilings above Conditioned Space Volume and below an Attic, Unconditioned Space Volume, Unrated Heated Space, Multifamily Buffer Boundary, Non-Freezing Space, or outdoor environment	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 Emittance: Same as Rated Home
Attics	Type: Same as Rated Home. If more than one type, maintain same proportional coverage for each type.
Doors	Area: Same as Energy Rating Reference 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[a]	

Building Component	Index Adjustment Design (IAD)
	Combined Infiltration flow rate plus mechanical Ventilation flow rate of 0.03 * CFA + 7.5 * (Nbr+1) cfm Infiltration flow rate shall be determined using the following envelope leakage rates: 5 ACH_{50} in IECC[69] Climate Zones 1-2 3 ACH_{50} in IECC[65] 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% Tier 1
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(1b) Non-electric Furnaces: natural gas Furnace in accordance with Table 4.2.2(1b) Non-electric Boilers: natural gas Boiler in accordance with Table 4.2.2(1b) Capacity: sized in accordance with Section 4.4.3.1 Installation Quality Grade of Forced-Air HVAC System with Furnace or Heat Pump: configured in accordance with Section 4.2.2.3.1 and modeled in accordance with Section 4.2.2.3.2.
Cooling systems	Fuel type: Electric Efficiency: in accordance with Table 4.2.2(1a) Capacity: sized in accordance with Section 4.4.3.1 Installation Quality Grade of Forced-Air HVAC System with Air Conditioner or Heat Pump: configured in accordance with Section 4.2.2.4.1 and modeled in accordance with Section 4.2.2.4 .2.
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

[69] (Normative Note) Climates zones shall be as specified by the 2006 IECC.

Building Component	Index Adjustment Design (IAD)
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 interior and exterior lighting shall be 75% Tier I

Table 4.3.1(1) Notes:

(a) The procedure for determining the combined air exchange rate resulting from infiltration combined with Dwelling Unit Mechanical Ventilation Systems is consistent with that shown in Table 4.2.2(1) table notes (g) and (h).

4.3.2. An Approved Software Rating Tool shall be used to determine the Energy Rating Index for the IAD (ERI_{IAD}).[70]

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

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

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

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

where:

IAF_{RH} = combined Index Adjustment Factor for Rated Home.
IAF_{CFA} = (2400/CFA) ^ [0.304 * (IAD_{SAVE})]
IAF_{Nbr} = 1+ [0.069 * (IAD_{SAVE}) * (Nbr-3)]
IAF_{NS} = (2/NS) ^ [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, temperature control point offsets of 2 ºF from 11 p.m. to 4:59 a.m. and 1 ºF from 5 a.m. to

[70] (Informative Note) The Residential Energy Services Network (RESNET) accredits energy rating software tools in accordance with RESNET Publication 002.

5:59 a.m. for heating and 2 ºF from 9 a.m. to 1:59 p.m. and 1 ºF from 2 pm to 2:59 p.m. 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[71] 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 sensible cooling loads calculated in accordance with Manual J, 8th Edition, ASHRAE *Handbook of Fundamentals*, or an equivalent computation procedure, using the following assumptions. Where an HVAC system installation Grade II or Grade III occurs, system sizing shall be adjusted accordingly, if necessary to meet the load, to account for capacity losses due to installation quality.

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-percent and 1-percent 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.

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

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, 8th 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.

[71] (Informative Note) Examples: HSPF, SEER and AFUE.

4.4.3.1.6. Heat Pump equipment capacity shall be sized to equal the larger of the building heating and sensible 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-percent and 1-percent 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 Equations 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, 8th 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 at least equal the larger of the building heating and sensible cooling loads calculated in accordance with these procedures. Heating equipment shall be sized to at least meet the building heating load and cooling equipment shall be sized to at least meet the building sensible cooling load.

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), Note r. 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[72]) shall be modified to represent the performance of the compressor and evaporator components alone[73]. 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:

$$\boldsymbol{SEER_{eq}} = \frac{(\boldsymbol{Cap} - (\boldsymbol{aux} \times \mathbf{3.41})) - \left(\boldsymbol{aux_{dweq}} \times \mathbf{3.41} \times \boldsymbol{N_{dweq}}\right)}{(\boldsymbol{Input} + \boldsymbol{aux}) + \left(\boldsymbol{aux_{dweq}} \times \boldsymbol{N_{dweq}}\right)}$$

(Equation 4.4-2)

where:

Cap = Chiller system output in Btu/hour.

[72] (Normative Note) For Commercial Variable Refrigerant Flow (VRF) Multi-Split Air Conditioning and Heat Pump Equipment, use IEER in place of SEER.

[73] (Informative Note) Such approaches are described in Cutler et al. 2011 and Fairey et al. 2004.

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[74] 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:

$$\boldsymbol{SEER_{eq}} = \frac{\boldsymbol{WLHP_{cap}} - \left(\frac{\boldsymbol{aux} \times \mathbf{3.41}}{\boldsymbol{N_{dweq}}}\right)}{\boldsymbol{Input} + \left(\frac{\boldsymbol{aux}}{\boldsymbol{N_{dweq}}}\right)} \qquad \textbf{(Equation 4.4-3)}$$

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:

$$Input = \frac{WLHP_{cap}}{EER}$$

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) = $GSHP_{pump}$ - $GSHP_{intp}$ + $GSHP_{fan}$

[74] (Informative Note) For example, this includes all power to run a Water Loop Heat Pump within the Dwelling Unit, not just the air handler energy.

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.

$GSHP_{fan}$: The external fan energy in Watts, $GSHP_{fan}$, shall be added for all periods of Heat Pump operation. $GSHP_{fan}$ = (Airflow in CFM * Fan Efficiency in Watts per CFM) where the Airflow in CFM shall be (400 * rated cooling Btu/h / 12,000) and the Fan Efficiency shall be 0.58, unless the system has been assessed in accordance with ANSI/RESNET/ACCA/ICC 310, in which case $GSHP_{fan}$ shall equal the actual Watt draw of the system. 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 [75]

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 [55]

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

[75] (Normative Note) Where COP is rated at both 17ºF and 47ºF, and software does not distinguish, use COP at 47ºF. Where COP is rated for part load and full load, and software does not distinguish, use COP at full load.

pump(s), the Auxiliary Electric Consumption for the Rated Home shall be determined as follows:

$$\boldsymbol{Eae = \frac{SP_{kW}}{N_{dweq}} \times 8760 + HPfan_{kW} \times (HLH + CLH)}$$ **(Equation 4.4-4)**

where:

SP_{kW} = Shared Pump power in kW[76]. 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 Boilers Serving One Unit. For a fossil fuel fired Boilers, 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 Boiler.

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:

$$\boldsymbol{Eae = ((\frac{SP_{kW}}{N_{dweq}}) + aux_{in}) \times HLH}$$ **(Equation 4.4-5)**

where:

SP_{kW} = Shared pump power in kW[77]. 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.

[76] (Normative Note) Where the pump serves common or commercial spaces in addition to the Dwelling Units, apportion the pump power using the ratio of the Rated Home's design heating load to the capacity of the heating system servicing that pump and dwelling unit, and using 1 for N_{dweq}.

[77] (Normative Note) Where the pump serves common or commercial spaces in addition to the Dwelling Units, apportion the pump power using the ratio of the Rated Home's design heating load to the capacity of the heating system servicing that pump and dwelling unit, and using 1 for N_{dweq}.

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).[78]

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 and the outdoor humidity ratio is less than 0.0115. 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).[79]

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).

[78] (Normative Note) Where COP is rated at both 17ºF and 47ºF, and software does not distinguish, use COP at 47ºF. Where COP is rated for part load and full load, and software does not distinguish, use COP at full load.
[79] (Normative Note) The Whole-House fan shall operate during hours of favorable outdoor conditions.

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 Approved by the entity adopting the use of this Standard shall be used based on current and historical local building practice and building codes, and for modular or manufactured housing, using 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 4.5.2.4 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).

Commented [RD2]: The table doesn't reference Standard 380 or provide other information on "on-site diagnostic tests". Should it?

4.5.2.3. The energy efficiency of the mechanical equipment set forth as building elements 11, 12 and 15 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:

Commented [RD3]: Should there be a reference for how on-site tests should be conducted?

$$\mathbf{Eff,rated = Eff,listed * Es,measured / Es,listed}$$

where:

Eff,rated = annual efficiency to use as input to the Rating.
Eff,listed = listed annual efficiency by manufacturer or directory.
Es,measured = measured steady state efficiency of system.
Es,listed = manufacturer's listed steady state efficiency under the same operating conditions found during measurement;

(b) Nameplate data;
(c) Manufacturer's data sheet;
(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), and 4.5.2(4).

4.5.2.4. The Air Conditioner, Furnace, and Heat Pump Installation Quality Grade set forth as building element 13 in Table 4.5.2(1) shall be determined by using Standard

ANSI/RESNET/ACCA/ICC 310. When information on the Installation Quality Grade cannot be determined, the values set forth in Table 4.5.2(5) shall be used.

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 (according to Table 4.2.2(4)).
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 (according to Table 4.2.2(5)). To determine the attic eave geometry determine the roof slope, eave height, ceiling framing height, and eave length.
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 test measurement, Infiltration Volume, Conditioned Space Volume.

Table 4.5.2(1) Minimum Rated Features	
Building Element	**Minimum Rated Feature**
10. Distribution System	System type, location, insulation value (duct and pipe), air leakage measurement and type (default estimate, duct pressurization), duct area measurement and type (default estimate, measured, or taken from detailed ACCA Manual D duct sizing take-offs).
11. Heating Equipment	Equipment type, location, capacity, efficiency (AFUE, HSPF, COP), boiler 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. Air Conditioner, Furnace, and Heat Pump Installation Quality Grade	These features shall be assessed in accordance with Standard ANSI/RESNET/ACCA/ICC 310 unless the default value of Grade III is assigned for the installation quality of the total duct leakage, Blower Fan airflow, Blower Fan watt draw, and refrigerant charge: • For Evaluation of Design Information: Completeness of all required HVAC design documentation, and compliance with design criteria. • For Total Duct Leakage Installation Quality: Total duct leakage, Conditioned Floor Area served by the system, number of returns, whether tested at rough-in or final, total duct leakage grade (Grade I, II, or III). If the testing exception is taken, then confirmation that the total amount of supply ductwork or distribution building cavities does not exceed 10 ft. in length and is entirely in Conditioned Space Volume. • For Blower Fan Volumetric Airflow Installation Quality: test method used, mode that testing was done in (heating or cooling), Blower Fan volumetric airflow, design-specified Blower Fan volumetric airflow, Blower Fan volumetric airflow grade (Grade I, II, or III). If using the Pressure Matching or Flow Grid method, then also Psop, Ptest, Qtest, whether turbulent conditions were encountered, and, for the Pressure Matching Method only, if the Fan Flowmeter was connected at a return grille or at the blower compartment. If using the OEM Static Pressure Table method, then also Blower Fan motor type, Blower Fan fan-speed setting, Ptop, Pfilter, elevation above sea level, and whether turbulent conditions were encountered. If the testing exception is taken, then confirmation that the total amount of supply ductwork or distribution building cavities does not exceed 10 ft. in length and is entirely in Conditioned Space Volume. • For Blower Fan Watt Draw Installation Quality: test method used, mode that testing was done in (heating or cooling), Blower Fan watt draw, Blower Fan volumetric airflow, Blower Fan watt draw grade (Grade I, II, or III).

Table 4.5.2(1) Minimum Rated Features	
Building Element	**Minimum Rated Feature**
	If using the analog utility revenue meter method, then also the Kh factor, number of meter wheel revolutions, and duration of test. • For Refrigerant Charge Installation Quality: test method used and refrigerant charge grade (Grade I or III). If the non-invasive method is used, then also the equipment's rated SEER value, design-specified Blower Fan volumetric airflow in cooling mode, design maximum total heat gain, metering device type, target subcooling value if metering device type is TXV/EEV, target superheat value if the metering device type is piston/capillary tube, return air dry-bulb temperature, return air wet-bulb temperature, outdoor air dry-bulb temperature, suction line temperature, liquid line temperature, and documentation of any site-specific installation values provided by the installing contractor. If the weigh-in method is used, then also collection of all required refrigerant system documentation from the installing contractor; total length of the liquid line, outside diameter of the liquid line, weight of the refrigerant required for the incremental liquid line length, total anticipated weight of refrigerant, total reported refrigerant weight, deviation in total refrigerant weight, and evaluation of geotagged photo(s).
14. Control Systems	Thermostat type.

Table 4.5.2(1) Minimum Rated Features	
Building Element	**Minimum Rated Feature**
15. Service Hot Water Equipment	For Residential Equipment - Equipment type, location, efficiency (Uniform Energy Factor and First Hour Rating; or Energy Factor), extra tank insulation R-Value, flow rates of showers and Bathroom sink 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 Bathroom sink 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).
16. Solar Domestic Hot Water Equipment	System type, collector type and area, orientation, tilt, efficiency, storage tank size, pipe insulation value.
17. 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.
18. 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 4.2.2.7.2.5
19. 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 4.2.2.7.2.9.
20. Range/Oven	Burner Energy Factor (BEF) and Oven Energy Factor (OEF) as defined in Section 4.2.2.7.2.7

Table 4.5.2(1) Minimum Rated Features	
Building Element	**Minimum Rated Feature**
21. 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 4.2.2.7.2.10.
22. 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 4.2.2.7.2.8.
23. 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.
24. Dwelling Unit Mechanical Ventilation System(s)	Ventilation strategy (Supply, Exhaust, or Balanced), equipment type (individual or shared), controls (continuous or programmed intermittent schedule), daily run time, measured exhaust airflow, measured supply airflow, system rated airflow and fan wattage.[80] 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.
25. Systems pre-conditioning Ventilation Air	System type (heating, cooling, both), efficiency, fan power, system rated airflow.
26. 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.
27. Dehumidification Equipment	Equipment type, capacity corresponding to 65 ^{o}F and 60 % relative humidity for portable dehumidifiers and 73 ^{o}F and 60 % relative humidity for whole-home dehumidifiers, integrated energy factor.

[80] (Informative Note) A source for fan wattage is the Certified Home Ventilating Products Directory available from the Heating and Ventilation Institute (HVI).

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[81]	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	Unconditioned Space Volume	40%	Not tested or listed by EPA

[81] (Informative Note) Such as in a fireplace.

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

Type	Location	Seasonal Efficiency	Notes
with Distribution System			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

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
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:[82]									
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]

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

[82] (Informative Note) For service hot water provided by a Boiler, use the efficiencies for Heating Boiler.

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

Mechanical Systems	Units	Rating
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 Air Conditioner, Furnace, and Heat Pump Installation Quality Grade Values

Parameter	Value
Blower Fan Airflow Deviation	F_{AF} = -25%
Blower Fan Watt Draw Efficiency	Blower Fan Efficiency = 0.58 W/CFM
Refrigerant Charge Deviation	F_{CHG} = -25%

5. 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.

5.1. Baseline Existing Home. The Baseline Existing Home Model for the purposes of determining the energy savings of an Existing Home Retrofit shall be the original configuration of the existing home, including the full complement of lighting, appliances and residual miscellaneous energy use as specified by Tables 4.2.2.5(1) and 4.2.2.5(2). The energy use of these end uses in the Baseline Existing Home Model shall be based on the original home configuration following the provision of Section 4.2.2.7.2

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

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

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

5.2.1. Where an existing appliance[83] 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.

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

5.2.3. Improvements in lighting and appliance energy use in the Improved Home Model shall be calculated in accordance with Section 4.2.2.7.2

5.3. Standard Operating Conditions.

5.3.1. 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 5.3.1(1).

Table 5.3.1 (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

[83] (Informative Note) Example: a refrigerator.

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.	

5.3.2. Air Distribution Systems.

5.3.2.1. 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 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.

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

5.3.2.2.1. 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.

5.3.2.2.2. 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.

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

5.4. Energy Savings Calculation.

5.4.1. 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 5-1.

$$\mathbf{kWh_{tot} = kWh_{elec} + kWh_{eq}} \qquad \textbf{(Equation 5-1)}$$

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.

5.4.2. 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.

5.4.3. The energy savings percentage of the retrofit shall be calculated as the Dwelling Unit total energy savings (kWh_{tot}) as determined by Section 5.4.2 divided by the Dwelling Unit total energy use (kWh_{tot}) of the Baseline Existing Home Model.

6. Economic Cost Effectiveness.

If Ratings are conducted to evaluate energy saving improvements to the home for the purpose of an energy improvement loan or energy efficient mortgage, indicators of economic cost effectiveness shall use present value costs and benefits, which shall be calculated in accordance with Equations 6-1 and 6-2.

$$\mathbf{LCC_E = P1*(1^{st}\ Year\ Energy\ Costs)} \qquad \textbf{(Equation 6-1)}$$

LCC_I = P2*(1st Cost of Improvements) **(Equation 6-2)**

where:

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

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

$LCC_S = LCC_{E,b} – LCC_{E,i}$ **(Equation 6-3)**

where:

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

Standard economic cost effectiveness indicators shall be calculated as follows:

$SIR = (LCC_S) / (LCC_I)$ **(Equation 6-4)**

$NPV = LCC_S - LCC_I$ **(Equation 6-5)**

where:

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

6.1. Calculation of Ratio Parameters. The ratios represented by parameters P1 and P2 shall be calculated in accordance with Equations 6-6a through 6-8d.[84]

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

or if DR = ER then:

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

where:

P1 = Ratio of Present Value Life Cycle Energy Costs to the 1st year Energy Costs.
DR = Discount Rate as prescribed in Section 0.
ER = Energy Inflation Rate as prescribed in Section 0.
nAP = Number of years in Analysis Period as prescribed in Section 6.2.

$P2 = DnPmt + P2_A + P2_B + P2_C - P2_D$ **(Equation 6-7)**

where:

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

P2 = Ratio of Life Cycle Improvement Costs to the first cost of improvements.
DnPmt = Mortgage down payment rate as prescribed in Section 0.
$P2_A$ = 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) **(Equation 6-8a)**

where:
PWFd = Present Worth Factor for the discount rate = 1/DR*[1-(1/(1+DR)^nAP)]
PWFi = Present Worth Factor for the mortgage rate = 1/MR*[1-(1/(1+MR)^nMP)]
DR = Discount Rate as prescribed in Section 0.
MR = Mortgage Interest Rate as prescribed in Section 0.
nAP = Number of years of the Analysis Period as prescribed in Section 0
nMP = Number of years of the Mortgage Period.

$P2_B$ = MFrac*PWinf **(Equation 6-8b)**

where:
MFrac = Annual O&M costs as a fraction of first cost of improvements.[85]
PWinf = Ratio of present worth discount rate to present worth general inflation rate.
= 1/(DR-GR)*{1-[((1+GR)/(1+DR))^nAP]}

[85] (Informative Note) The maintenance fraction includes all incremental costs over and above the operating and maintenance cost of the "standard" measure. Where components of a system have various lifetimes, the longest lifetime is allowed to be used and the components with shorter lifetimes are allowed to be included as a maintenance cost at the present value of their future maintenance cost. The maintenance fraction is also allowed to be used to represent the degradation in performance of a given system. For example, photovoltaic (PV) systems have a performance degradation of about 0.5-percent per year. This value can be added to the maintenance fraction for PV systems to accurately represent this phenomenon in this cost calculation procedure.

or if DR = GR then:
= nAP/(1+DR)
GR = General Inflation Rate as prescribed in Section 0.

$P2_C$ = Sum {1/[(1+(DR-GR))^(Life*i)]} for i=1, n **(Equation 6-8c)**

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

$P2_D$ = RLFrac / ((1+DR)^nAP) **(Equation 6-8d)**

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

6.2. Standard Economic Inputs. The economic parameter values used in the cost effectiveness calculations specified in Section 6.1 shall be determined in accordance with Sections 6.2.1 through 6.2.10.[86]

6.2.1. General Inflation Rate (GR) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Consumer Price Index for Urban Dwellers (CPI-U) as reported by the U.S. Bureau of Labor Statistics,[87] where ACR shall be calculated in accordance with Equation 6-9.

ACR = [(endVal)/(startVal)]^[1.0/((endYr)-(startYr))]-1.0 **(Equation 6-9)**

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

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

6.2.3. Mortgage Interest Rate (MR) shall be defaulted to the greater of the 5-year and the 10-year average of simple interest rate for fixed rate, 30-year mortgages computed from the

[86] (Informative Note) RESNET shall annually publish Standard Economic Input values for the General Inflation Rate (GI), Discount Rate (DR), Mortgage Interest Rate (MR), Down Payment Rate (DnPmt) and Energy Inflation Rate (ER) determined in accordance with this section that can be used by Approved economic calculation tools.
[87] (Informative Reference) http://www.bls.gov/CPI/#tables.

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.

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

6.2.5. Energy Inflation Rate (ER) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Bureau of Labor Statistics, Table 3A, Housing, Fuels and Utilities, Household Energy Index[88] as calculated using Equation 6-9.

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

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

6.2.8. Remaining Life Fraction (RLFrac) shall be calculated in accordance with Equation 6-10.

RLFrac = (nAP/Life) – [Integer (nAP/Life)] **(Equation 6-10)**

or if Life > nAP then:

RLFrac = (Life-nAP) / nAP

where:

Life = Useful service life of the improvement(s).

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

6.2.9.1. For New Homes the improvement costs shall be the full installed cost of the improvement(s) less the full installed cost associated with the minimum provisions of the energy code or standard in effect where the building is located less any financial incentives that accrue to the home purchaser.

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

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

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

7. 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 emission savings, minimum reporting requirements, and specification of the types of Ratings that are performed in accordance with this Standard.

7.1. Rating Requirements.

7.1.1. General. The Energy Rating for a home shall be determined in accordance with Sections 7.1.1.1 through 7.1.1.4.

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

7.1.1.2. For a new, to-be-built home, the procedures of Section 4.5 shall be used to collect required data.

7.1.1.3. 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.

7.1.1.4. Estimates completed using Sections 7.1.1.3 shall comply with Sections 7.1.1.4.1 through 7.1.1.4.3.

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

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

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

7.1.2. Savings Estimates.

7.1.2.1. Energy Cost Savings. Where determined, the energy cost savings for the Rated Home shall be calculated in accordance with Sections 7.1.2.1.1 and 7.1.2.1.2.

7.1.2.1.1. 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).[89]

7.1.2.1.2. Energy Cost Savings. Energy cost saving estimates of the Rated Home[90] for Confirmed, Sampled and Projected Ratings shall be calculated in accordance with Sections 7.1.2.1.2.1 through 7.1.2.1.2.4.

7.1.2.1.2.1. 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.

7.1.2.1.2.2. Rated Home energy costs shall be determined by fuel type, applying the same energy price rates used for the Energy Rating Reference Home.

7.1.2.1.2.3. 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.

7.1.2.1.2.4. Estimated energy cost savings with respect to the Typical Existing Home shall be determined in accordance with Sections 7.1.2.1.2.4.1 and 7.1.2.1.2.4.2.

7.1.2.1.2.4.1. 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.

7.1.2.1.2.4.2. 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.

[89] (Informative Note) RESNET will compile and publish statewide, revenue-based electricity price data that can be used in accordance with this section by Approved Software Rating Tools for the calculation of electricity costs.
[90] (Informative Note) Depending on the metering configuration for the Dwelling Unit, the energy cost savings for the Rated Home may be realized by the occupant or by the building owner.

7.1.2.2. Emission The emissions of the Rated Home shall be calculated in accordance with Sections 7.1.2.2.1.

7.1.2.2.1. Emissions. Emissions for all homes shall be calculated in accordance with Sections 7.1.2.2.1.1 and 7.1.2.2.1.2.

7.1.2.2.1.1. For electricity use, data for the sub-region annual total output emission rates published by Environmental Protection Agency's 2019 eGrid database[91] for electricity generation shall be used to calculate emissions.[92] except CO_2 emissions, which shall be calculated using the Cambium database[93,94] for the most recent year's Mid-case, average hourly CO_2 generation rate (*co2_rate_avg_load_enduse*: $kgCO_2$ per MWh_{enduse}) for the local ZIP Code.

7.1.2.2.1.2. For fossil fuel use, emissions shall be calculated using the emission factors given in Table 7.1.2(1).

Table 7.1.2(1) Emission Factors for Household Combustion Fuels[95]

Fuel Type	Units	MBtu per Unit	CO_2 lb/MBtu	NOx lb/MBtu	SO_2 lb/MBtu
Natural Gas	Therm	0.1000	117.6	0.0922	0.0006
Fuel Oil #2	Gallon	0.1385	161.0	0.1300	0.0015
Liquid Petroleum Gas (LPG)	Gallon	0.0915	136.6	0.1421	0.0002

7.1.2.2.2. Emission Savings. Estimated emission savings for the Rated Home shall be calculated in accordance with Sections 7.1.2.2.2.1 through 7.1.2.2.2.3.

7.1.2.2.2.1. The Energy Rating Reference Home emissions shall be determined by fuel type by applying the emissions determined in

[91] (Informative Reference) http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
[92] (Informative Note) RESNET will compile and publish annual total output emission rate data for NOx, SO_2 and CO_2 in accordance with the provisions of this section that can be used by Approved Software Rating Tools for the calculation of emissions.
[93] https://cambium.nrel.gov/
[94] Gagnon, Pieter, Will Frazier, Elaine Hale, and Wesley Cole, 2020. "Cambium Documentation: Version 2020." Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-78239. https://www.nrel.gov/docs/fy21osti/78239.pdf
[95] (Informative Note) Developed from the U.S. EPA AP 42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1, Chapter 1: External Combustion Sources.

accordance with Section 7.1.2.2.1 to the individual fuel types of the Energy Rating Reference Home.

7.1.2.2.2.2. The Rated Home emissions shall be determined by fuel type by applying the same emission data used for the Energy Rating Reference Home in Section 7.1.2.2.2.1 above.

7.1.2.2.2.3. For Confirmed, Sampled and Projected Ratings, estimated emission savings shall be calculated in accordance with Sections 7.1.2.2.2.3.1 and 7.1.2.2.2.3.2.

7.1.2.2.2.3.1. Estimated emission savings with respect to the Energy Rating Reference Home shall be the difference between the emissions of the Energy Rating Reference Home and the emissions of the Rated Home.

7.1.2.2.2.3.2. Estimated emission savings with respect to the Typical Existing Home shall be determined in accordance with Sections 7.1.2.2.2.3.2.1 and **7**.1.2.2.2.3.2.2.

7.1.2.2.2.3.2.1. For each fuel type, multiply the Energy Rating Reference Home emissions by 1.3 to determine the Typical Existing Home emissions by fuel type.

7.1.2.2.2.3.2.2. Estimated emission savings with respect to the Typical Existing Home shall be the difference between the emissions of the Typical Existing Home and the emissions of the Rated Home.

7.1.3. Reports. All reports generated by an Approved Software Rating Tool shall, at a minimum, contain the information specified by Sections 7.1.3.1 through 7.1.3.6.

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

7.1.3.2. The name of the Certified Rater conducting the Rating.

7.1.3.3. The name of the Approved Rating Provider under whose auspices the Certified Rater is certified.

7.1.3.4. The date the Rating was conducted.

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

7.1.3.6. 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.

7.1.4. Rating Types. There shall be four Rating types in accordance with Sections 7.1.4.1 through 7.1.4.4.

7.1.4.1. Confirmed Rating. A Rating type that encompasses one individual Dwelling Unit and is conducted in accordance with Sections 7.1.4.1.1 through 7.1.4.1.3.

7.1.4.1.1. All Minimum Rated Features of the Rated Home shall be verified through inspection and testing in accordance with Section 4.5.

7.1.4.1.2. 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.

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

7.1.4.2. Projected Rating. A Rating type that encompasses one individual Dwelling Unit and is conducted in accordance with Sections 7.1.4.2.1 through 7.1.4.2.6.

7.1.4.2.1. 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.

7.1.4.2.2. 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).

7.1.4.2.3. 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).

7.1.4.2.4. 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).

7.1.4.2.5. The Minimum Rated Features of Rated Homes that were determined in Sections 7.1.4.2.1 through 7.1.4.2.3 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.

7.1.4.2.6. 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."

7.1.4.3. Sampled Ratings for Detached Dwelling Units. A Rating type that encompasses a set of Dwelling Units that is conducted in accordance with Sections 7.1.4.3.1 through 7.1.4.3.3. Sampled Ratings are only permitted if Approved for use by the authority having jurisdiction.

7.1.4.3.1. 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.[96]

7.1.4.3.2. 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.

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

[96] (Informative Note) Section 600 of the RESNET *Mortgage Industry National Home Energy Rating Standards* or equivalent may be used as criteria for inspection and testing Minimum Rated Features of a sample set of Rated Homes.

7.1.4.4. Sampled Ratings for Attached Dwelling Units. A Rating type that encompasses a set of Dwelling Units that is conducted in accordance with Sections 7.1.4.4.1 through 7.1.4.4.7. Sampled Ratings are only permitted if Approved for use by the authority having jurisdiction.

7.1.4.4 1. Selecting unit types. A Projected Rating shall be performed on each unique Dwelling Unit type, in accordance with Section 7.1.4.2. 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 percent), same Conditioned Floor Area (±10 percent, not to exceed ±100 square feet), and same ceiling height (±0.5 feet) 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.

7.1.4.4.2. 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.

7.1.4.4.2.1. 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.

7.1.4.4.3. 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 7.1.4.4.5.

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

7.4.4.4.1. 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.[97]

7.1.4.4.5. 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.

7.1.4.4.5.1. 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.[98] The final Energy Rating for each Dwelling Unit type shall report the Energy Rating Index that comports with these inputs.

7.1.4.4.5.1.1. 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.

7.1.4.4.5.1.2. 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.

---

[97] (Informative Note) Section 600 of the RESNET *Mortgage Industry National Home Energy Rating Standards* or equivalent may be used as criteria for inspection and testing Minimum Rated Features of a sample set of Rated Homes.

[98] (Normative Note) A Sampled Rating, where a specific Minimum Rated Feature was directly verified in each unit and not verified using Sampling, is permitted to use the verified performance rather than the worst value for that feature.

7.1.4.4.6. Labeling. Every unit in the Sampled Project shall be provided with a label in accordance with Section 7.3, which shall additionally contain one of the following statements as applicable.

7.1.4.4.6.1. "This unit has not been fully inspected or tested and has received a Sampled Rating in accordance with Section 7.1.4.4 of ANSI Standard 301."

7.1.4.4.6.2. "This unit has been fully inspected and tested and has received a Confirmed Rating in accordance with Section 7.1.4.1 of ANSI Standard 301."

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

7.1.4.5. Threshold Ratings. A rating type that encompasses one individual Dwelling Units that is conducted in accordance with Sections 7.1.4.5.1 through 7.1.4.5.3.

7.1.4.5.1. The Threshold Specifications used in the Worst-Case Analysis of the Minimum Rated Features of Threshold Ratings 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.

7.1.4.5.2. All Minimum Rated Features shall be field-verified through inspection and testing of each Dwelling Unit in accordance with Section 4.4 to meet or exceed the Threshold Specifications. The field inspection and testing data shall not be used to modify Threshold Ratings.

7.1.4.5.3. Threshold Ratings shall be subjected to Quality Assurance requirements adopted by an Approved Rating Provider.

7.1.5. 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.

7.2. Innovative Design Requests.

7.2.1. 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:

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

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

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

7.2.1.4. 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.

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

7.2.2. 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.

7.3. Labeling. Energy Rating labels shall, at a minimum, contain the information specified by Sections 7.3.1 through 7.3.8.

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

7.3.2. Energy Rating Index of the home.

7.3.3 CO_2 Index for the home, calculated in accordance with Section 8.

7.3.4 Projected CO_2 emissions for the home, calculated in accordance with Sections 7.1.2.2.1.1 and 7.1.2.2.1.2.

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

7.3.6. Projected annual energy cost of the home,[99] calculated in accordance with energy price rate provisions of Section 7.1.2.1.1.

7.3.7. Name and address of the Approved Rating Provider.

7.3.8. Date of the Energy Rating.

8. CO_2 Rating Index. The CO_2 Index shall be calculated for the Rated Home in accordance with equation 8-1 using the provisions of Sections 8.1 through 8.5

CO_2 Index = ACO2 / ARCO2 * 100 **(Equation 8-1)**

where:
ACO2 = Annual hourly CO_2 emissions from the Rated Home
ARCO2 = Annual hourly CO_2 emissions from the CO_2 Index Reference Home

8.1 The CO_2 emission factors for household combustion fuel use shall be those given in Table 7.1.2(1).

8.2 The CO_2 emission factors for electricity use shall be the levelized CO_2 emission factors calculated using the Cambium database[100,101] for the Low Renewable Energy Cost Scenario for the Long-Run Marginal end use CO_2 generation rate (*co2_lmer_enduse*: $kgCO_2$ per MWh_{enduse}) for the local ZIP Code using equation 8-2 with a starting year of 2025.[102]

$$\boldsymbol{LRMER_{levelized}} = \frac{\sum_{t=0}^{n-1}\frac{LRMER_t}{(1+d)^t}}{\sum_{t=0}^{n-1}\frac{1}{(1+d)^t}} \quad \textbf{(Equation 8-2)}$$

where:
$LRMER_t$ = long-run marginal emission rate for year t
d = real social discount rate = 0.03

---

[99] (Informative Note) The projected energy cost shown on the label might not reflect the projected energy costs to be paid by the occupant as metering configurations can result in certain energy costs and end-uses being paid by the building owner.
[100] https://cambium.nrel.gov/
[101] Gagnon, Pieter, Will Frazier, Elaine Hale, and Wesley Cole, 2020. "Cambium Documentation: Version 2020." Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-78239. https://www.nrel.gov/docs/fy21osti/78239.pdf
[102] (Informative note) National Renewable Energy Laboratory (NREL) provides a spreadsheet tool for the calculation of levelized CO_2 emission rates. The NREL spreadsheet tool uses the input parameters specified by this section as inputs to the spreadsheet tool.

n = evaluation period in years = 25

8.3 The CO_2 emission factors shall be applied to the hourly Purchased Energy by fuel type for both the Rated Home and the CO_2 Index Reference Home.

8.4 The CO_2 Index Reference Home shall be identical to the Energy Rating Reference Home except that it shall use electricity for all energy end uses.

8.5 Where reported, the CO_2 savings for the Rated Home shall be the CO_2 emissions for the CO_2 Index Reference Home minus the CO_2 emissions for the Rated Home.

9. 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.

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 90.1-2016, "Energy Standard for Buildings Except Low-Rise Residential Buildings." American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA, 2012

ANSI/CRRC S100-2021, "Standard Test Methods for Determining Radiative Properties of Materials," Cool Roof Rating Council, Portland, OR. www.coolroofs.org

ANSI/RESNET/ACCA/ICC 310-2020, “Standard for Grading the Installation of HVAC Systems” and ANSI approved Addenda. Residential Energy Services Network, Oceanside, CA.

ANSI/RESNET/ICC 380-2022, “Standard for Testing Airtightness of Building, Dwelling Unit, and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems; and Airflow of Mechanical Ventilation Systems” and ANSI Approved Addenda. Residential Energy Services Network, Oceanside, CA.

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

ASTM C177-13, “Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.” ASTM International, West Conshohocken, PA.

ASTM C518-17, “Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.” ASTM International, West Conshohocken, PA.

ASTM C727-12, “Standard Practice for Installation and Use of Reflective Insulation in Building Constructions.” ASTM International, West Conshohocken, PA.

ASTM C976-96, “Thermal Performance of Building Assemblies by Means of a Calibrated Box.” ASTM International, West Conshohocken, PA.

ASTM C1015-06 (2011)e1, “Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation.” ASTM International, West Conshohocken, PA.

ASTM C1114-06(2013), “Standard Test Method for Steady-State Thermal Transmission Properties by Means of The Thin-Heater Apparatus.” ASTM International, West Conshohocken, PA.

ASTM C1224-15, “Standard Specification for Reflective Insulation for Building Applications.” ASTM International, West Conshohocken, PA.

ASTM C1320-10 (2016), “Standard Practice for Installation of Mineral Fiber Batt and Blanket Thermal Insulation for Light Frame Construction.” ASTM International, West Conshohocken, PA.

ASTM C1321-15, “Standard Practice for Installation and Use of Interior Radiation Control Coating Systems (IRCCS) in Building Construction.” ASTM International, West Conshohocken, PA.

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

ASTM C1549-16 “Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer.” ASTM International, West Conshohocken, PA. https://doi.org/10.1520/C1549-16

ASTM C1743-12, “Standard Practice for Installation and Use of Radiant Barrier Systems (RBS) in Residential Building Construction.” ASTM International, West Conshohocken, PA.

ASTM C1848-17a, “Standard Practice for Installation of High-Pressure Spray Polyurethane Foam Insulation for the Building Enclosure.” ASTM International, West Conshohocken, PA.

ASTM E2178-13, “Standard Test Method for Air Permeance of Building Materials,” ASTM International, West Conshohocken, PA.CSA B55.1-12, (2012). “Test method for measuring efficiency and pressure loss of Drain Water Heat Recovery Units.” CSA Group, Mississauga, Ontario, Canada L4W 5N6.

ASTM E903-20 “Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres.” ASTM International, West Conshohocken, PA. https://doi.org/10.1520/E0903-20

ASTM G197-14 “Standard Table for Reference Solar Spectral Distributions: Direct and Diffuse on 20° Tilted and Vertical Surfaces. ASTM International, West Conshohocken, PA. https://doi.org/10.1520/G0197-14

CSA B55.2-12, (2012). “Drain Water Heat Recovery Units.” CSA Group, Mississauga, Ontario, Canada L4W 5N6.

CRRC-1 *Product Rating Program Manual, Appendix 8,* 2021. Cool Roof Rating Council, Portland, OR, www.coolroofs.org

FTC Rule 460, 16 CFR Part 460, “Labeling and Advertising of Home Insulation: Trade Regulation Rule.” Federal Trade Commission, Washington, D.C.

IBC, 2018 *International Building Code*. International Code Council, 500 New Jersey Avenue, NW, Washington, DC.

IECC, 2018 *International Energy Conservation Code*. International Code Council, 500 New Jersey Avenue, NW, Washington, DC.

IRC, 2018 *International Residential Code*. International Code Council, 500 New Jersey Avenue, NW, Washington, DC.

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

10. Informative References.

American National Standards Institute, (ANSI) http://www.ansi.com

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

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

Cutler, D., Winkler, J., Kruis, N., Christensen, C., and Brandemuehl, M. 2013. *Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations*. NREL Technical Report. Golden, CO.

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

Efficient Window Collaborative, Window Selection Tool, https://www.efficientwindows.org/

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

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

Fairey, P., D.S. Parker, B. Wilcox and M. Lombardi. 2004. "Climate Impacts on Heating Seasonal Performance Factor (HSPF) and Seasonal Energy Efficiency Ratio (SEER) for Air Source Heat Pumps." *ASHRAE Transactions*. Atlanta, GA.

International Code Council, http://www.iccsafe.org

LBL RESFEN 6.0 User Manual, Lawrence Berkley Laboratories, Berkley, CA, https://windows.lbl.gov

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

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

1. Normative Appendix A

Inspection Procedures for Insulation Grading and Assessment

A-1. Insulation

In order to meet the requirements of a Grade I or Grade II insulation rating, the insulation material shall be installed in accordance with the minimum installation requirements of this Appendix and the requirements specified by ASTM standards C727, C1015, C1743, C1320, C1321 and C1848 as described below in the insulation grading section.

Installations not complying with the minimum installation requirements of this Appendix, the relevant ASTM standard for the type insulation, or the Grade I or Grade II coverage requirements shall be considered Grade III installations. Grade III installations shall be recorded and shall be modeled as specified by Section 4.2.2.3.2 of this Standard.

A-1.1 Minimum General Installation Requirements:

1. Insulation shall be installed according to manufacturer's installation instructions.
2. No air spaces shall be allowed between different insulation types or systems.

   Exception: When claiming the R-Value of an enclosed airspace in accordance with the ASHRAE *Handbook of Fundamentals*, Chapter 26, Table 3 or the ASHRAE 90.1-2016 Section A9-4 (or addendum ac to the 2013 edition) or ASTM C1224.

3. Insulation shall be installed to the density and thickness required to attain the specified R-Value. The base R-Value of fibrous batt 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 Estimated R-values for Compressed Fiber Glass Batt Insulation (NAIMA BI506).

4. Insulation shall fill around obstructions including, but not limited to, framing, blocking, wiring, pipes, etc. without substantial gaps or voids.

A-1.2 Minimum Specific Application Requirements:

1. Insulation installed in framed floor assemblies shall be in substantial and permanent contact with the subfloor.

   Exception: The floor framing cavity insulation shall be permitted to be in contact with the topside of sheathing or continuous insulation installed on the bottom side of floor framing where combined with insulation that meets or exceeds the minimum wood frame wall R-Value in Table 402.1.2 of the International Energy Conservation Code (IECC)

and that extends from the bottom to the top of all perimeter floor framing members. Perimeter floor insulation is not required to extend from the bottom to the top of framing members that separate the Unconditioned Space Volume of the floor cavity from the Conditioned Space Volume.

The cavity insulation between floor joists, beams or other horizontal floor supports that create cavities under the subfloor shall be permitted to be in direct contact with any additional continuous insulation attached to the underside of the horizontal supports. The combination of both cavity and continuous insulation shall meet or exceed the minimum required floor R value in Table 402.1.2 of the IECC. Instances of reflective insulation system installed beneath hydronic floors are not required to meet this standard.

1. For rim or band joist applications, insulation shall be in substantial and permanent contact with rim or band joist framing and tightly fitted to intersecting solid floor joists, wood i-joists or extend continuously through open web floor trusses. Interior sheathing or air barrier is not required provided there is an air barrier on the exterior side or the insulation material is installed as an air barrier material.

2. Air permeable insulation in ventilated attics and vented sloped roofs shall have an effective air barrier (wind block, air chute, or eave baffle) securely fastened and installed at the eave or soffit edge vent of every cavity. The effective air barrier shall extend up and beyond the surface of the insulation or to the ridge vent.

A-1.3 Minimum Specific Material Requirements:

A-1.3.1 Insulated Sheathing:

1. If used as an air barrier, edges and joints shall be taped or otherwise air sealed in accordance with the manufacturer's recommendations.
2. Edges not supported directly on sheathing or framing shall be tightly fitted to one another without substantial gaps.
3. Sheathing shall be carefully fitted and taped or otherwise air sealed around obstructions in accordance with the manufacturer's recommendations.
4. When two or more layers of insulation are installed the joints shall be staggered. Only the joints of one of the layers shall be required to be taped or otherwise air-sealed where that layer is designated to be an air-barrier.
5. Where used as an Approved water-resistive barrier (WRB), sheathing joints, Fenestration, and service penetrations shall be taped or otherwise air sealed in accordance with the manufacturer's installation instructions.

A-1.3.2 Fibrous Batt Insulation:

1. Insulation shall fill the entire cross-section of the cavity being insulated[103].

   For floor cavities, where insulation is not required to maintain permanent contact with the subfloor, insulation shall also extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed.

2. Insulation shall be enclosed on all six sides with durable materials.

   Exceptions:
   a. Insulation installed in attics above ceilings shall not require an air barrier on the exterior side.
   b. Insulation installed under floors directly above an unvented crawl space shall not require an air barrier on the exterior side.
   c. Insulation installed in rim or band joists located in conditioned space shall not require an air barrier on the interior side.
   d. Insulation installed on conditioned basement and conditioned crawlspace walls where an air barrier material meeting code requirements for exposed applications and tested in accordance with ASTM E2178 (air permeance less than 0.004 cfm/ft^2) is installed on the interior side.

3. Faced batts shall be stapled to the face of the studs or side stapled to the studs with no buckling of the stapling tabs or the tabs shall be permitted to be left unstapled. Faced batt products without tabs and friction fit products shall not be required to be stapled when installed in walls. Compression of face stapled batts shall be graded in accordance with the criteria outlined in Sections A-2.1.1.1, A-2.1.2.1, or A-2.1.3.
4. When side stapled, compression is permitted only along edges to the depth of the stapling tab.
5. Insulation shall be closely fitted around obstructions including, but not limited to, framing, blocking, wiring, pipes, etc. to avoid substantial gaps, voids or compression.

A-1.3.3 Blown or Sprayed Fibrous Loose Fill Insulation:

1. Insulation containment fabric or system that is side stapled shall not be stapled more than ½ inch back from the face of the stud.
2. Insulation shall be rolled or trimmed flat to allow installation and contact with interior sheathing or finish material.
3. Insulation shall fill the entire cross-section of the cavity being.[104]

[103] (Informative Note) For example, in a wall cavity the insulation shall extend side-to-side from vertical stud to vertical stud and top-to-bottom from the top plate to the bottom plate. In a floor cavity the insulation shall extend side-to-side from floor joist to floor joist and side-to-side from rim/band joist to rim/band joist.
[104] (Informative Note) For example, in a wall cavity the insulation shall extend side-to-side from vertical stud to vertical stud and top-to-bottom from the top plate to the bottom plate. In a floor cavity the insulation shall extend side-to-side from floor joist to floor joist and side-to-side from rim/band joist to rim/band joist.

For floor cavities, where insulation is not required to maintain permanent contact with the subfloor, insulation shall also extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed.

4. Blown insulation shall meet the manufacturer's stated recommendations for density and coverage in order to meet the required R-Value and to minimize or prevent settling.
5. Insulation shall be enclosed on all six sides with durable materials.

Exceptions:

a. Air permeable insulation installed on the top side of the ceiling in unconditioned attics shall not require an air barrier on the exterior.
b. Insulation installed under floors that are directly above an unvented crawl space shall not require an air barrier on the exterior side.
c. Insulation installed in rim or band joists located in conditioned space shall not require an air barrier on the interior side.

6. Insulation shall be installed around obstructions including, but not limited to, framing, blocking, wiring, pipes, etc. as to avoid substantial gaps, voids or compression.

A-1.3.4 Open-Cell Spray Polyurethane Foam (SPF) Insulation:

1. Installers shall meet the manufacturer's recommended training requirements and shall complete the online health and safety training for SPF provided by the Center for Polyurethanes Industry.
2. Spray foam shall be well-bonded to the substrate, including framing and sheathing.
3. Insulation, installed at a minimum thickness to be air impermeable per ASTM E2178 (air permeance less than 0.004 cfm/ft^2) and in-contact with the substrate shall be permitted to serve as the air barrier.
4. When insulation extends beyond the wall cavity it shall be trimmed to allow installation and contact with interior sheathing or finish material.
5. Insulation shall fill the cavity to within at least ½ inch of the face of the studs.

Exception: The cavity fill requirement is met when the required R-Value is achieved using a thickness that is less than the cavity depth.

A-1.3.5 Closed-Cell Spray Polyurethane Foam (SPF) Insulation:

1. Installers shall meet the manufacturer's recommended training requirements and shall complete the online health and safety training for SPF provided by the Center for Polyurethanes Industry.
2. Spray foam shall be well-bonded to the substrate, including framing and sheathing.
3. Closed-cell insulation, installed at a minimum thickness of 1.5 inches and in contact with the substrate, shall be permitted to serve as a component of the continuous air barrier.

Exception: Thicknesses less than 1.5 inches considered air-impermeable with appropriate ASTM E2178 data (air permeance less than 0.004 cfm/ft^2) from manufacturer data sheet or code evaluation report prepared by an organization accredited for product certification per ISO-17065 or other source approved by an authority having jurisdiction.

A-2. Insulation Grading

A-2.1 Grading Criteria for Batt, Loose fill, Open and Closed Cell Polyurethane Spray Foam Insulation and Insulated Sheathing

A-2.1.1 Grade I (Minor Defects)

Shall meet ASTM-specified installation requirements in the applicable standards C1015, C1320 and ASTM C1848 and shall meet the following appropriate material installation grading requirements.

A-2.1.1.1 Batt or Loose fill Insulation

When installing batt, or loose-fill insulation, no more than 2% of the total insulated area shall be compressed below the thickness required to attain the labeled R-Value or contain gaps or voids in the insulation. These areas shall not be compressed more than $^3/_4$ inch of the specified insulation thickness in any given location. Voids extending from the interior to exterior of the intended insulation areas shall not be permitted.

A-2.1.1.2 Open-Cell Polyurethane Spray Foam Insulation (cavity not filled and not trimmed)

When installing open-cell polyurethane spray foam, the average of all thickness measurements shall be greater than the specified thickness required to obtain the specified R-Value. No more than 2 percent of the insulated area shall contain voids or be more than ¾ inch below the specified thickness. The minimum installed thickness shall not be less than 1 inch below the specified thickness at any point. Voids extending from the interior to the exterior of the intended insulation areas shall not be permitted.

A-2.1.1.3 Open-Cell Polyurethane Spray Foam Insulation (cavity filled and trimmed)

When installing open-cell polyurethane spray foam, no more than 2 percent of the total insulated area (cavity) shall be below the thickness required to attain the specified R-value or contain gaps or voids in the insulation. The minimum installed thickness shall not be less than $^1/_2$ inch below the specified thickness at any point. Voids extending from the interior to exterior of the intended insulation areas shall not be permitted.

A-2.1.1.4 Closed-Cell Polyurethane Spray Foam
When installing closed-cell polyurethane spray foam the average of all thickness measurements shall be greater than the specified thickness required to obtain the specified R-Value. No more than 2 percent of the insulated area shall contain voids or be greater than ½ inch less than the specified thickness. The minimum installed thickness shall not be less than ¾ inch below the specified thickness at any point. Voids extending from the interior to exterior of the intended insulation areas shall not be permitted.

A-2.1.1.5 Insulated Sheathing
Insulated sheathing insulation installations meeting the minimum installation, application, and material requirements above. Voids exceeding $^{1}/_{8}$ inch through interior to exterior of the intended insulation areas shall not be permitted. Joints and other gaps or separations in sheathing used as an air barrier, vapor retarder or drainage plane shall be taped or sealed.

A-2.1.2 Grade II (Moderate Defects)
Installations not complying with the minimum installation requirements in ASTM standards C1015, C1320, and ASTM C1848, and the appropriate Grade I material installation grading requirements shall be considered a Grade II or Grade III installation in accordance with their level of defect.

A-2.1.2.1 Batt or Loose fill Insulation
When installing batt, or loose fill insulation, no more than 15 percent of the total insulated area (cavity) shall be compressed or contain gaps or voids in the insulation. These areas shall not be missing or compressed more than $^{3}/_{4}$ inch of the specified insulation thickness in any given location. Inset staples are allowed for batt insulation. Voids through interior to exterior of the intended insulation areas shall not be permitted.

A-2.1.2.2 Open-Cell Polyurethane Spray Foam Insulation (cavity not filled and not trimmed)
When installing open-cell polyurethane spray foam the average of all thickness measurements shall be greater than the specified thickness required to obtain the specified R-Value. No more than 15 percent of the insulated area shall contain voids. The minimum thickness shall not be less than $^{3}/_{4}$ inch below the specified thickness at any point. Voids extending from the interior to the exterior of the intended insulation areas shall not be permitted.

A-2.1.2.3 Open-Cell Polyurethane Spray Foam Insulation (cavity filled and trimmed)
When installing open-cell polyurethane spray foam, no more than 15 percent of the total insulated area (cavity) shall be below the thickness required to attain the specified thickness or contain gaps or voids in the insulation. The minimum installed

thickness shall not be less than $^1/_2$ inch below the specified thickness at any point. Voids extending from the interior to exterior of the intended insulation areas shall not be permitted.

A-2.1.2.4 Closed-Cell Polyurethane Spray Foam
When installing closed-cell polyurethane spray foam the average of all thickness measurements shall be greater than the specified thickness required to obtain the specified R-Value. No more than 15 percent of the insulated area shall contain voids. The minimum thickness shall not be less than $^3/_4$ inch below the specified thickness at any point. Voids extending from the interior to exterior of the intended insulation areas shall not be permitted.

A-2.1.3 Grade III (Substantial Defects)
Installations not complying with the minimum installation requirements in ASTM standards C1015, C1320 and C1848 and the appropriate Grade I or Grade II material installation grading requirements shall be considered a Grade III installation.

Grade III installations shall be recorded and shall be modeled as specified by Section 4.2.2.3.2 of this Standard.

A-2.2 Structural Insulated Panels (SIPs) Grading Criteria

1. Sealing of panel joints shall meet the manufacturer's requirements. Where the manufacturer does not have specific joint sealing details, the Structural Insulated Panel Association's (SIPA) typical joint sealing details shall be used. SIPA details are available at https://www.sips.org.
2. Use spray foam to seal penetrations through the SIP panels.
3. Any damaged area shall be repaired.
4. All gaps and penetrations through SIPs including windows, doors and foundation or roof connections shall be air sealed with expanding foam compatible with the SIP materials.

A-2.2.1 Grade I (Minor Defects)
Shall meet the minimum installation requirements for SIP products above and the following requirements:.

1. SIP panels shall be properly aligned and unsealed penetrations extending from the interior to exterior of the panels shall not be permitted.
2. Two percent or less of the total area of the SIPS panels have damage which is unrepaired, including but not limited to, cutouts for electrical boxes, pipes and other penetrations.

A-2.2.2 Grade II (Moderate to Frequent Defects)
Shall meet the minimum installation requirements for SIPS products above and the following requirements:

1. Greater than 2 percent and less than 5 percent of the total area of the SIP panels have damage which is unrepaired, including but not limited to, cutouts for electrical boxes, pipes and other penetrations.
2. SIP panels shall be properly aligned and unsealed penetrations extending from the interior to exterior of the panels shall not be permitted.

A-2.2.3 Grade III (Major Defects)
SIP panel installations not complying with the minimum installation requirements and Grade I or Grade II requirements above shall be considered a Grade III installation.

Grade III installations shall be recorded and shall be modeled as specified by Section 4.2.2.3.2 of this Standard.

A-2.3 Reflective/Radiant Grading Criteria

Regarding thermal performance claims or R-Values:

1. R-Value claims for the airspace adjacent to a reflective insulation product shall be based on average cavity depth (where not less than ½ inch), heat flow direction which represents the application (wall, ceiling or floor), temperature of the airspace surfaces relative to the specific wall assembly, location of the airspace in the assembly and design climate conditions.
2. When utilizing R-Values claims for the airspace adjacent to a reflective insulation product, the airspace shall be a totally enclosed and unventilated cavity that minimizes airflow into or out of it in accordance with ASTM C727.
3. Where utilizing R-Values based on testing in accordance with ASTM C1224, the reflective insulation product shall be installed as tested. R-Value claims for the assembly including the airspace shall be based on ASTM C1224 or per the current Federal Trade Commission (FTC) Rule 460 requirements. The assembly that is tested for thermal resistance shall be representative of the field assembly.
4. Reflective airspaces behind cladding or otherwise located to the exterior side of the air barrier layer for the assembly shall not claim R-Values based on having an airspace, except where the cladding and the perimeter of the airspace creates a totally enclosed and unventilated cavity.

A-2.3.1 Reflective Insulation in Ceilings, Walls and Floors
Reflective insulation products include types with multiple layers, reflective bubble and reflective foam. Refer to the manufacturer's instructions for the product's installation details.

1. The products shall be permitted to be either face or side (inset) stapled and shall be permanently attached to the framing member.
2. When side- or inset- stapled, reflective insulation shall be installed at the depth in the cavity to attain the required airspace(s). Refer to manufacturer's installation details for the specific application including required airspace dimensions. Where the cavity

is partitioned to provide two or more airspaces that are each claimed for R-Value contribution, the attachment of the reflective material separating the spaces shall be installed against the framing without any gaps in order to minimize air leakage between the airspaces.

3. When face-stapled, the material width shall match the framing width.[105]

   Exception: Nonstandard cavity widths.

4. When face-stapled, the staple tabs shall be aligned with the direction of the framing.
5. When reflective insulation is to serve as a vapor retarder, the tabs are overlapped or taped when face-stapled. When inset stapled, the edges shall be attached to the sides, top and bottom of the framing.
6. Reflective insulation and radiant barriers (sheet type) materials shall not be laid directly on top of the attic floor or insulation materials installed above the ceiling.
7. Reflective insulation and radiant barriers installed under slabs shall not claim R-Values based on having an airspace.
8. Reflective airspaces behind cladding or otherwise located to the exterior side of the air barrier layer for the assembly shall not claim R-Values based on having an air-space, except where the cladding and perimeter of the airspace creates a totally enclosed and unventilated cavity.

A-2.3.1.1 Grade I (Minor Defects)
Shall meet the minimum installation requirements in ASTM C727 and shall also meet the following area coverage requirements:

Two percent or less of the area is not insulated such that the building envelope exterior sheathing (wall) is visible from the building's interior.

A-2.3.1.2 Grade II (Moderate to Frequent Defects)
Shall meet the minimum installation requirements in ASTM C727 and shall also meet the following area coverage requirements:

Greater than 2 percent and less than 10 percent of the area which is available for insulation is not insulated such that the building envelope exterior sheathing (wall) is visible from the building's interior.

A-2.3.1.3 Grade III (Substantial Defects)
Installations not complying with the minimum installation requirements in ASTM C727 and Grade I or Grade II area coverage requirements above shall be considered a Grade III installation.

Grade III installations shall be recorded and shall be modeled as specified by Section

[105] (Informative Note) For example, 16 inch wide material is used for 16 inch on-center framing.

4.2.2.3.2 of this Standard.

A-2.3.2 Attic Radiant Barriers

Minimum Requirements:

1. Attic radiant barriers shall be installed with an airspace adjacent to the low emittance (metallic) surface(s).
2. When the radiant barrier only has one low emittance surface, it shall be on the bottom side (in the direction of the ceiling).
3. Attic and/or roof ventilation shall be maintained. Roof, gable and soffit vents shall not be covered.
4. The radiant barrier shall be installed on gable ends.
5. The radiant barrier shall be firmly secured.

Attic radiant barriers shall be permitted to be installed using one of the following three methods:

RB Method 1: Deck applied – aluminum faced oriented strand board or plywood; radiant barriers applied in this manner shall be perforated.
RB Method 2: Draped – radiant barrier draped over the trusses or rafters.
RB Method 3: Truss applied – radiant barrier stapled to the bottom of the top cord of the roof truss or rafter.

A-2.3.2.1 Grade I (Minor Defects)
Shall meet the minimum installation requirements in ASTM C1743 and shall also meet the following area coverage requirements:

1. Two percent or less of the attic facing roof decking is bare wood or does not include low-emittance.
2. Two percent or less of the surface has contaminates, particles or ink on the surface.[106]
3. Radiant barrier is installed to cover the face of the rafter (Method 3 only).

A-2.3.2.2 Grade II (Moderate to Frequent Defects)
Shall meet the minimum installation requirements in ASTM C1743 and shall also meet the following area coverage requirements:

1. An area greater than two percent and less than or equal to ten percent of the attic facing roof decking is bare or does not include low-emittance.
2. An area greater than two percent and less than or equal to ten percent of the surface has contaminates, particles or printed information on the surface.
3. Radiant barrier is inset stapled (Method 3 only).

[106] (Informative Note) For example, dirt, printing of product identification, etc.

A-2.3.2.3 Grade III (Substantial Defects)
Installations not complying with the minimum installation requirements in ASTM C1743 and Grade I or Grade II area coverage requirements above shall be considered a Grade III installation.

Grade III installations shall be recorded and shall be modeled as specified by Section 4.2.2.3.2 of this Standard.

Additionally, radiant barrier installations which have the following issues shall be deemed to be Grade III:
1. Radiant barrier is not permanently attached.
2. Radiant barrier is not perforated (RB Method 1 only).

A-2.3.3 Interior Attic Radiation Control Coatings (IRCCs)
IRCC materials are a liquid applied with an emittance of 0.25 or less.

Application Requirements:

1. The IRCCS shall be in permanent contact with the underside of the roof deck and should cover the underside of all roof deck and gable surfaces.
2. The coating shall render the application surface to an overall metallic finish that in some cases retains the texture characteristics of the wood surface.
3. The coating surface shall be dry to the touch.

A-2.3.3.1 Grade I (Minor Defects)
Shall meet the minimum installation requirements in ASTM C1321 and shall also meet the following area coverage requirements:

Less than 2 percent of the surface is bare wood or discolored.

A-2.3.3.2 Grade II (Moderate to Frequent Defects)
Shall meet the minimum installation requirements in ASTM C1321 and shall also meet the following area coverage requirements:
Greater than 2 percent and equal to or less than 10 percent of the surface is bare wood or discolored.

A-2.3.3.3 Grade III (Substantial Defects)
Installations not complying with the minimum installation requirements in ASTM C1321 and Grade I or Grade II area coverage requirements above shall be considered a Grade III installation.

Grade III installations shall be recorded and shall be modeled as specified by Section 4.2.2.3.2 of this Standard.

Normative Appendix B

Inspection Procedures for Minimum Rated Features

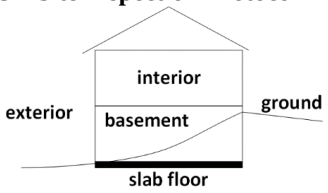
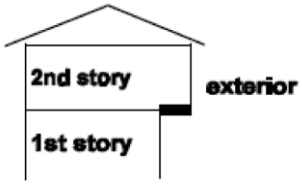
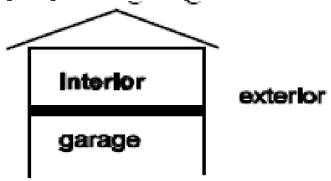
Table of Contents

General....B-2
Foundation/Floor Assembly....B-3
Wall Assembly....B-11
Roof/Ceiling Assembly....B-19
Rim/Band Joists or Floor Perimeters....B-24
Doors....B-25
Windows....B-26
Skylights....B-29
Passive Solar System....B-30
Air Leakage....B-32
Heating and Cooling Distribution System....B-33
Heating and Cooling Equipment....B-37
Service Hot Water (SHW) Equipment....B-52
Service Hot Water Distribution....B-54
Solar Domestic Hot Water Equipment....B-56
Light Fixtures....B-58
Refrigerator(s)....B-59
Dishwasher(s)....B-60
Range/Oven....B-61
Clothes Washer....B-62
Clothes Dryer....B-63
Ceiling Fans....B-64
Dwelling Unit Mechanical Ventilation System(s)....B-65
Corridor Ventilation....B-67
On-Site Power Production....B-68

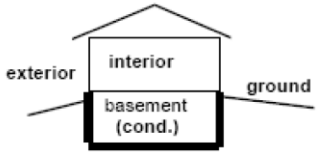
General		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Applies to relevant Minimum Rated Features (MRF) from Table 4.5.2(1)	Record field inspections and performance tests by digital/electronic means. All records shall be kept for a minimum of 3 years.	Clearly document the following: • The date and time of the inspection/test; • The name of the Certified Rater, Approved Inspector conducting the inspection/test; • The Dwelling Unit being inspected/tested containing sufficient detail to indicate the location of the inspection including the complete address of the inspected/tested Dwelling Unit; • If included in the Energy Rating and present in the Dwelling Unit, a minimum of one representative photo of items #2 (Wall Assembly), #3 (Roof/Ceiling Assembly), #11 (Heating Equipment), #12 (Cooling Equipment) #15 (Service Hot Water Equipment), and #24 (Mechanical Ventilation System) from Table 4.5.2(1) that reflect the reported data; and • If testing is conducted in the Dwelling Unit, a photo of the recorded test results or a report generated by automated software that communicates with the testing device showing the test result. Each photo and/or report shall include the time/date that it was obtained.

Building Element: Floor/Foundation Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Gross Area and perimeter	Measure floor/foundation dimensions.	For floors and slabs, measure dimensions of floor to calculate area. For slab-on-grade, also calculate total perimeter and perimeter exposed to other conditioned spaces. For conditioned basements and crawlspaces, measure dimensions of walls and floor to calculate area. Divide walls into above and below grade sections. Dimensions shall be measured and rounded to the nearest foot, and the square footage calculated and rounded to the nearest square foot. Dimensions shall use exterior measurements starting at the exterior finished surface of the outside wall. Openings to the floor below shall not be included in the square footage calculation, except for stairways. Stairways and associated landings are counted as square footage on both the starting and ending levels. The "footprint" of protruding chimneys or bay windows shall not be included. The "footprint" of other protrusions like a cantilever when it includes finished floor area shall be included. For Detached Dwelling Units, the square footage of separate finished areas that are connected to the main body of the house by conditioned hallways or stairways shall be included. Each unique floor exposure, construction type and R-Value combination shall be calculated separately.
Foundation type	Determine and record whether foundation is a crawlspace, basement, slab on grade or combination and whether it meets the criteria for Conditioned Space Volume, Unconditioned Space Volume, Unrated	Use the definitions in Section 3 to determine and record whether a crawlspace or basement is Conditioned Space Volume, Unconditioned Space Volume, Unrated Conditioned Space, or Infiltration Volume.

Building Element: Floor/Foundation Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
	Conditioned Space, or Infiltration Volume.	
Floor type	Identify floor over crawlspace.	A crawlspace is a foundation condition with a vertical dimension between the floor joists and ground or slab that is 6 feet or less. Vented crawlspaces have some form of vent or louver in the crawlspace walls or are constructed in a manner such that air moves freely from outside the walls to inside the crawlspace. Unvented crawlspaces are constructed without any form of vents or louvers in the wall and are constructed to exclude air from outside the walls to inside the crawlspace. Unvented crawlspaces may also be Conditioned Space Volume.
	Identify slab-on-grade floor/foundation.	A slab-on-grade is recognized by the absence of either a crawlspace or basement. A slab-on-grade is constructed by pouring a concrete slab directly on the ground as the floor for the Dwelling Unit. 
	Identify floor over full basement.	A full basement has characteristics like a crawlspace, except that the clear vertical dimension is greater than 6 feet.
	Identify walkout basement.	A walkout basement is a basement where a portion of the slab floor is on-grade and a portion is below grade.

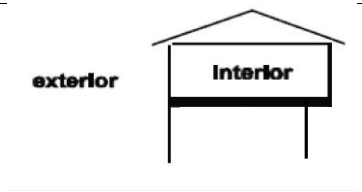
Building Element: Floor/Foundation Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		
	Identify floor over exterior space.	A floor that extends horizontally beyond the story below and is exposed to the exterior underneath is considered floor to exterior. 
	Identify floor over garage.	A floor that extends horizontally beyond the story below and is exposed to the  Identify floors over a garage.
	Identify floor of Attached Dwelling Unit over garage.	Where the floor of an Attached Dwelling Unit is exposed to a garage space beneath it that is not shared with other Dwelling Units, that garage space shall be considered Unconditioned Space Volume. Otherwise, that floor of the Attached Dwelling Unit is facing one of the four space types described in the next entry:

Building Element: Floor/Foundation Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
	Identify floor of Attached Dwelling Unit over Multifamily Buffer Boundary, Unrated Conditioned Space, Unrated Heated Space or Non-Freezing Space.	1. *Floor above Multifamily Buffer Boundary* – The space directly below the Dwelling Unit has no heating or cooling system or the space is not designed to maintain space conditions at 78 °F (26 °C) ± 5°F for cooling and 68 °F (20 °C) ± 5°F for heating. 2. *Floor above Unrated Conditioned Space* – The space directly below the Dwelling Unit is serviced by a 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. 3. *Floor above Unrated Heated Space* – The space directly below the Dwelling Unit is outside of the Conditioned Space Volume and only interacts with the Rated Home via the shared services located within. This space is not cooled.

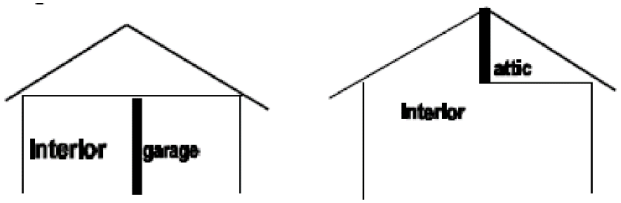
		4. *Non-Freezing Space* – The temperature of the space directly below the Dwelling Unit varies with outside temperature but is heated as necessary to stay at or above 40°F.
Framing members	Determine and record the framing size and spacing of all framed floor segments that separate one space type from another type or the exterior.	Determine and record the framing member size (either 16" or 24" on-center) of each applicable framed floor segment through visual observation.[107] Use the framing spacing to determine the default framing fraction per Table 4.2.2(6).
Interior surface condition	Determine and record if the inside surface condition of floor is exposed or covered.	*Covered or insulated* – Floors including but not limited to covered with wall-to-wall carpet or foam board insulation are considered covered. Floors with only area rugs are not considered covered. *Exposed or not insulated*– Floors including but not limited to covered with tile, linoleum, vinyl, or wood are considered exposed.
Foundation insulation	Determine and record type, grade, location, and thickness of foundation insulation and resultant R-Value.	Use the inspection procedures in Normative Appendix A to determine and record the insulation type and grade. Visually confirm insulation location as interior, exterior or both[108] sides of the foundation wall, record R-Value and measure thickness. Visually confirm whether insulation product is installed for 100% of required area/perimeter and visually confirm and record R-Value. If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness. 

[107] (Informative Note) For example, through direct observation of the framing or by observing the spacing of fasteners in the rim joist from the outside.
[108] (Informative Note) For example, foam core ICF- insulated concrete forms.

		If 100% of the area/perimeter of the foundation insulation cannot be visually confirmed, inspect according to the protocol below:
		1. Visually confirm insulation product is installed for a minimum of 25% of the area/perimeter of the foundation insulation specified for insulation, and visually confirm and record R-Value. Where R-Value cannot be determined during site observation, the manufacturer's data sheet shall be used. Use the inspection procedures in Normative Appendix A to determine and record the grade of insulation. The grade of the visually confirmed area shall be applied to the rest of the area unless photos show any additional deficiencies, in which case the grade recorded shall be the worst case documented. 2. Collect photos to confirm installation at several site locations and in sufficient detail to confirm thickness, type, and grade of the insulation installation. If foundation insulation cannot be visually verified immediately after installation, it may be verified through comprehensive photographs that comply with the requirements given above.
Floor insulation	Determine and record type, grade, and thickness of floor insulation and resultant R-Value.	Use the inspection procedures in Normative Appendix A to determine and record the type and grade of floor insulation. For dense pack or spray foam applications, multiply the thickness of the insulation in inches by the appropriate R-Value per inch based on the insulation type in order to calculate the total floor insulation R-Value.

		
Slab-on-grade insulation	Determine and record type, grade, location and thickness of slab-on-grade insulation and resultant R-Value.	Slab perimeter insulation is installed vertically, either on the outside of the slab extending above and/or below grade or between the foundation wall and the slab itself. Under slab insulation is installed horizontally, either along the slab perimeter or underneath the entire slab.

		Use the inspection procedures in Normative Appendix A to determine and record the type and grade. Visually confirm location as horizontal or vertical, record R-Value and measure thickness. Visually confirm whether insulation product is installed for 100% of required area/perimeter and visually confirm and record R-Value. If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness. If 100% of the area/perimeter of the slab insulation cannot be visually confirmed, inspect according to the protocol below: 1. Visually confirm insulation product is installed for a minimum of 25% of the area/perimeter of the slab specified for insulation and visually confirm and record R-Value. If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness. Use the inspection procedures in Normative Appendix A to determine and record the grade of insulation. The grade of the visually confirmed area shall be applied to the rest of the area unless photos show any additional deficiencies, in which case the grade recorded shall be the worst case documented. 2. Collect photos to confirm installation at several site locations and in sufficient detail to confirm thickness, type and grade of the insulation installation. If slab insulation cannot be visually verified immediately after installation, it may be verified through comprehensive photographs that comply with the requirements given above.

Building Element: Wall Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Gross Area	Determine and record surface area of all walls.	Measure linear perimeter of the walls and round to the nearest foot. Measure the interior wall height of the walls and round to the nearest foot. Use these measurements to calculate surface area and round to the nearest square foot. Each unique wall exposure, construction type and R-Value combination shall be calculated separately. Where the portion of the wall assembly is occupied by through-wall AC sleeves, PTAC, or PTHP penetrations, that portion of the wall shall be modeled separately, using an R-value of 2 or less.
Wall exposure	Determine and record whether walls border Exterior, Unconditioned Space Volume, Multifamily Buffer Boundary, Unrated Conditioned Space, Unrated Heated Space, Non-Freezing Space or Adjacent Building.	1. *Wall to Exterior* – Walls border exterior space.  2. *Wall to Unconditioned Space Volume* – Walls border Unconditioned Space Volume as defined in Section 3.  3. *Wall to Multifamily Buffer Boundary* – The space adjacent to the Dwelling Unit wall has no heating or cooling system or the space is not designed to maintain space conditions at 78 °F (26 °C) ± 5°F for cooling and 68 °F (20 °C) ± 5°F for heating.

Building Element: Wall Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		4. *Wall to Unrated Conditioned Space Volume* – The space adjacent to the Dwelling Unit wall is serviced by a 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. 5. *Wall to Unrated Heated Space* – The space adjacent to the Dwelling Unit wall is outside of the Conditioned Space Volume and only interacts with the Rated Home via the shared services located within. This space is not cooled. 6. *Wall to Non-Freezing Space* – The temperature of the space directly adjacent to the Dwelling Unit wall varies with outside temperature but is heated as necessary to stay at or above 40°F. 7. *Wall to Adjacent Building* – When a Dwelling Unit is directly adjacent to another building, the walls adjacent to that other building shall be considered exterior walls. However, if there is no air space present between the two buildings and the building that is adjacent is inspected and determined to meet the definition of Conditioned Space Volume, then the wall shall be considered adiabatic.
Construction type	Determine and record the structural system of walls.	*Framed walls* – Wood studs are typically located at 16" or 24" on center along the wall. Measure and record the predominant on-center spacing of the studs. *Masonry walls* – Masonry walls are load-bearing walls constructed of concrete ~~or~~ brick or block. A wood framed wall with brick veneer is not a masonry wall. Also record the siding or finish material on the exterior of the wall. If interior framing is present, record whether it is wood or metal. *Foam core walls (SIP)* – Foam core walls are a sandwich panel consisting of a foam center with outer layers of structural sheathing, gypsum board or outer finish materials. Foam core panels may be structural or nonstructural.

Building Element: Wall Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		Structural panels are also known as structural insulated panels (SIPs). Nonstructural panels are frequently used in post and beam construction.

		Log walls – Log walls are solid wood walls, using either milled or rough logs or solid timbers. Some homes have the appearance of solid log walls yet are actually wood frame walls with siding that looks like solid logs inside and out. Some log walls are manufactured with insulated cores. Assume no added insulation exists in a log wall unless manufacturer's data sheet and/or a visual inspection confirms insulation type and thickness.
Framing members	Determine and record the framing size spacing and type of all framed wall segments that separate one space type from another or from the exterior.	Determine the framing member size, spacing (either 16" or 24" on-center), and framing type of each applicable framed wall segment through visual observation. To determine framing member size: • Where framing is visible: If insulation is in place, carefully probe depth using tape measure, wire probe, or foam insulation depth gauge while disturbing as little of the assembly as possible. • Where framing is not visible: Measure the width of the window or door jambs; Subtract the widths of the wall coverings and sheathing materials;[109] Compare the remaining width to 3.5" for a 2x4 wall or 5.5" for a 2x6 wall; Where exposed garage walls exist, examine them for reference although they will not always be the same as other walls; Where a wall does not come close to the framing width of a 2x4 or 2x6, inspect for continuous insulation on the inside or outside of the walls or look for "double stud" or "strapped" walls or other factors that account for a thickness greater than 5.5". For brick veneer walls, assume 4.5" - 5" for brick, airspace and sheathing material.

[109] (Informative Note) Approximately, 0.25" to 1.0" for stucco, 0.5" to 0.6" for interior sheetrock and 0.5" to 0.75" for other exterior siding materials.

		To determine framing member spacing: Use visual observation.[110] To determine framing member type: Designate the type as Advanced if, through visual observation, the segment meets all of the requirements for the Advanced framing type defined in Section 4.2.2.1.1. Designate the type as Structural Insulated Panel if it meets the definition contained within this standard. If not, or if the framing cannot be observed, then designate the type as Standard. Use the framing spacing and framing type to determine the default framing fraction per Table 4.2.2(6). As an alternative to determining the framing spacing and framing member type, if a framing plan with the design framing fraction and a professional engineer's stamp has been obtained, then verify through visual observation that the actual assembly in field matches the framing plan. If it does match, then the design framing fraction may be used, per Section 4.2.2.1.2.

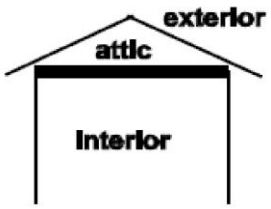
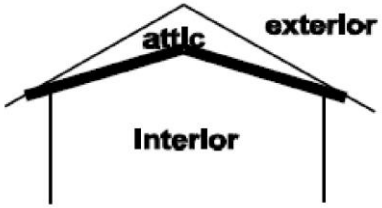
[110] (Informative Note) For example, through direct observation of the framing or by observing the spacing of fasteners in the top plate from above.

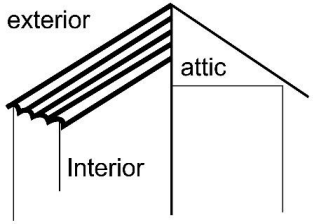
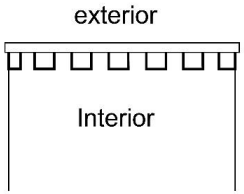
		Check the framing member size on all sides of the Dwelling Unit. When an addition has been added, be sure to check the walls of the addition separately. Where the Dwelling Unit has more than one story, check the framing member size for each floor.
Wall insulation installation	Determine and record type, grade and thickness of framed wall insulation and resultant R-Value.	Use the inspection procedures in Normative Appendix A to verify the insulation type and grade of the insulation installed in the framed wall stud cavity. Visually confirm and record R-Value and measure thickness. If insulation is observed, but the R-Value cannot be determined during site observation, the manufacturer's data sheet shall be used.
	Determine and record type, grade and thickness of continuous exterior insulation and resultant R-Value.	Use the inspection procedures in Normative Appendix A to determine and record the insulation type and grade. Visually confirm whether insulation product is installed for 100% of area specified for insulation and visually confirm and record R-Value and measure thickness. If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness. If 100% of the area of the exterior insulation cannot be visually confirmed, inspect according to the protocol below: 1. Visually confirm insulation product is installed for a minimum of 25% of the area specified for insulation and visually confirm and record R-Value and measure thickness. If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness. Use the inspection procedures in Normative Appendix A to determine and record the type and grade of insulation. The grade of the visually confirmed area shall be applied to the rest of the area unless photos show any additional deficiencies, in which case the grade recorded shall be the worst case documented.

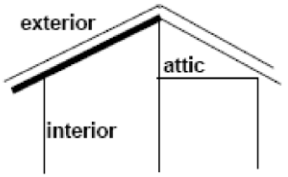
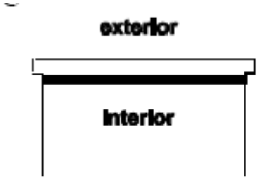
		2. Photos to confirm installation at several site locations and in sufficient detail to confirm thickness, type, and grade of the insulation installation. If exterior insulation cannot be visually verified immediately after installation, it may be verified through comprehensive photographs that comply with the requirements given above.
Existing insulation in walls	Determine and record if wall insulation exists in existing Dwelling Unit.	Check at plumbing outlet under sink or in order of preference, remove cable outlet plate, telephone plate, electrical switch plates or electrical outlet plates on exterior walls. Probe the cavity around the exposed plate with a nonmetal device. Determine and record type of insulation. Inspect outlets/switch plates on each side of the Dwelling Unit to verify that all walls are insulated. Multiply the wall framing member size in inches by the R-Value per inch. Use 3.5" for 2x4 walls and 5.5" for 2x6 walls constructed after 1945. When an addition has been added, check the walls of the addition separately. Where the Dwelling Unit has one more than one story, check each floor.
Color	Determine and record the color of the exterior walls.	Identify the color of the walls according to Table 4.2.2(4), except where test data are provided for wall surfaces in accordance with ASTM C1549 or ASTM E903 using the ASTM G197 air-mass 1.5 sun-facing global vertical solar spectral irradiance for the measurement of Solar Reflectance. [111] The Solar Absorptance value is obtained by subtracting the measured Solar Reflectance value from the number one (Solar Absorptance = 1 – Solar Reflectance).
Thermal mass	Determine and record type and thickness of all mass walls.	Where the Dwelling Unit's walls are constructed of concrete, masonry or brick (other than brick veneer), determine and record their type and thickness.[112] 1. Solid concrete walls (poured)

[111] (Normative Note) Solar Reflectance is permitted to be measured in accordance with the CRRC-1 Product Rating Program Manual Appendix 8 "Standard Test Method for Determining the Directional-Hemispherical Solar Reflectance of Materials Using a Directional-Hemispherical Portable Reflectometer" with the ASTM G197 air-mass 1.5 sun-facing global vertical solar spectral irradiance.
[112] (Informative Note) For example, check window opening for wall thickness.

		Measure the thickness of the poured concrete wall in inches. 2. Concrete Masonry Unit Measure the thickness of the wall in inches. Inspect for vermiculite or perlite insulation or other additional insulation.

Building Element: Roof/Ceiling Assembly		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Gross Area	Obtain measurements of all roof/ceiling areas.	Measure the linear perimeter of the ceiling area and round to the nearest foot and use these measurements to calculate surface area of the ceiling and round to the nearest square foot. When a ceiling area is vaulted, it is necessary to calculate dimensions geometrically. Each unique roof/ceiling exposure, construction type and R-Value combination shall be calculated separately.
Ceiling exposure	Determine and record ceiling exposure.	Identify the ceiling as one of the four following types. **1. Ceiling to attic.** When the ceiling has attic space above, even when the ceiling is vaulted as in a scissor truss, it is considered "ceiling to attic." Compare the vaulted ceiling angle against the angle of the roof. Where the ceiling angle is lower, there is attic space above the ceiling. Also check for an attic access either separate or from an attic over another part of the building.   **2. Ceiling to exterior.** When the ceiling has no attic space above even when the ceiling is flat, it is considered "ceiling to exterior."

		3. Ceiling to Multifamily Buffer Boundary. When the ceiling of the Attached Dwelling Unit has non-exterior, non-attic space directly above that has no heating or cooling system or the space is not designed to maintain space conditions at 78 °F (26 °C) ± 5°F for cooling and 68 °F (20 °C) ± 5°F for heating, it is considered "ceiling to Multifamily Buffer Boundary." **4. Ceiling to Unrated Conditioned Space** When the ceiling of the Attached Dwelling Unit has unrated space directly above, which may be another Dwelling Unit or another conditioned space in the building, that is conditioned by a 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, it is considered "ceiling to Unrated Conditioned Space."
Construction type	Determine and record ceiling construction type.	Framed ceilings fall into two categories. **1. Roof on exposed beams or rafters.** When you look up from inside the room, you will see exposed beams or rafters.   **2. Finished framed ceiling**. When a ceiling is framed, but you cannot see the framing because the ceiling is finished with drywall, plaster or paneling, record it as a finished framed ceiling.

		 
Framing members	Determine and record the size and spacing of all framed roof/ceilings segments that separate one space type from another type or from the exterior.	Determine and record the framing member size and spacing (either 16" or 24" on-center) of each applicable framed roof/ceiling segment through visual observation.[113] Use the framing spacing to determine the default framing fraction per Table 4.2.2(6).
Ceiling insulation	Determine and record type, grade, and thickness of insulation in framed ceiling and/or attic and resultant R-Value.	Determine and record the insulation R-Value that exists in the attic/ceiling unless it is ceiling to Unrated Conditioned Space. Use the following method for calculating the overall ceiling R-Value: • Use the inspection procedures in Normative Appendix A to determine and record the type and grade of the ceiling insulation present; • Record when the insulation is a combination of more than one type; • In the attic, measure the average depth in four places. Record whether the cavity insulation leaves the framing elements exposed, or covers them; when covered, record the thickness that covers the framing; and • Multiply the R-Value per inch of the material by the depth of the insulation. When there is no access to the attic or framed ceiling, a default R-Value shall be used based on current and historical local building practice and building code.

[113] (Informative Note) For example, through direct observation of the framing or by observing the spacing of the rafters or the fasteners in the exterior top plate, eve, or gable from the outside.

Roof cladding type	Determine and record roof cladding type	Identify the type of roofing surface. Some common types include asphalt shingle, pebble/gravel built-up roof, tile roof, wood shingle roof, rubber roof/roof coating, or metal roof.
Roof/attic eave construction.	Determine geometric configuration of the attic eaves at exterior wall	Determine the roof slope in inches of rise per foot of run.[114] Determine the eave height at the exterior wall surface from the top of the wall to the bottom of the roof ventilation baffle (if vented at eaves) or bottom of the roof sheathing whichever is applicable. Determine the height of the ceiling framing members above the ceiling finish material. Measure the full length of the attic eave perimeter where insulation depth is restricted by the roof slope. Determine the full thickness R-value and depth (in inches) of the ceiling insulation.
Roof color	Determine and record the color of the roof	Identify the color and material of the Roof according to Table 4.2.2(5), except where test data are provided for roof surfaces in accordance with ANSI/CRRC S100 for the measurement of Solar Reflectance. The Solar Absorptance value is obtained by subtracting the measured Solar Reflectance value from the number one (Solar Absorptance = 1 – Solar Reflectance).
Roof deck insulation	Determine and record type, grade, and thickness of roof deck insulation and resultant R-Value.	Identify the location of the roof deck insulation. The insulation can be either above or below roof deck. Use the inspection procedures in Normative Appendix A to verify the insulation type and grade. Visually confirm whether insulation product is installed for 100% of required area and visually confirm and record R-Value and measure thickness. If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness. If 100% of the roof area cannot be visually confirmed, inspect according to the protocol below:

[114] Measurement devices are available for making this measurement from inside the attic.

		• Visually confirm insulation product is installed for a minimum of 25% of the area specified for insulation and visually confirm and record R-Value and measure thickness. • If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness. Use the inspection procedures in Normative Appendix A to determine and record the grade of insulation. • The grade of the visually confirmed area shall be applied to the rest of the area unless photos show any additional deficiencies, in which case the grade recorded shall be the worst case documented. • Collect photos to confirm installation at several site locations and in sufficient detail to confirm thickness, type, and grade of the insulation installation. • If roof deck insulation cannot be visually verified immediately after installation, it may be verified through comprehensive photographs that comply with the requirements given above.

Building Element: Rim/Band Joists or Floor Perimeters		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Rim/band joist insulation installation	Inspect rim/band/floor perimeter insulation of Dwelling Unit during installation.	In wood-framed buildings, the rim joist is the band joist around the perimeter of the floor joists over a basement or crawlspace or between 2 stories of the building. In other taller multistory buildings, these intermediate floor perimeters may be metal-framed or solid concrete. Use the inspection procedures in Normative Appendix A to determine and record the insulation type and grade of insulation. Measure the depth of insulation at the rim/band joist and between stories in a multistory building. If insulation is observed without a labeled R-Value, the manufacturer's data sheet shall be used to determine and record the R-Value based on installed thickness.
Existing insulation in rim/band joists	Determine and record if rim/band insulation exists in existing Dwelling Unit.	**Crawlspace or Basement** From the basement or crawlspace, visually identify and measure the depth of insulation at the rim joist. Use the inspection procedures in Normative Appendix A determine and record the grade of insulation. Between Stories Look for access to the area from a garage or a utility access trap door. Visually identify and measure insulation where it exists. If no access is found, insulation is only assumed to exist at the rim joist between stories when: • Insulation was found at the rim joist at the top of the crawlspace or basement in the same building; and/or • Insulation is found in the walls of the same building. Otherwise, assume no rim joist insulation exists.

Building Element: Doors		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Area	Determine and record the area of doors.	Measure the width and height of the door and round to the nearest inch. Use these measurements to calculate the area of the door(s) by multiplying the rounded width times the rounded height and round that result to the nearest tenth of a square foot. Each unique door type and R-Value combination shall be calculated separately.
Construction type	Determine and record construction type of doors.	Determine and record whether the door(s) is fiberglass, metal or wood by making a close inspection of its texture, inspecting its side view or lock cut out. Alternatively, confirm by examining the door for a descriptive label or review the product manufacturer's data sheet.
Insulation	Determine and record doors insulation value.	Determine and record the door(s) insulation U-factor value and, if applicable, SHGC by examining the door for a descriptive label or review the product manufacturer's data sheet. Where insulation values cannot be determined, record default values based on the local building code in effect at the time of construction.
Presence of a door seal	Inspect for the presence of a door seal on the door where the blower door is installed.	Identify the door where the blower door is to be setup for the airtightness test. Inspect for the presence of a door seal installed to minimize air leakage between the door and door frame. Document the presence, installation, quality and condition of the door seal. If door seal is not present or properly installed the applicable penalty shall be added to the blower door results per ANSI/RESNET/ICC 380 section 4.3.2.4.

Building Element: Windows		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Area	Determine and record area of windows.	Measure the width and height of the rough opening for the window and round to the nearest inch. Use these measurements to calculate window area and round to the nearest tenth of a square foot. For existing homes or where the rough opening cannot be measured, window dimensions shall be measured from the outside edge of the window framing and include the width of the window frame. Each combination of window type U-value, and orientation shall be calculated separately.
Construction type	Determine and record window material and Glazing characteristics.	**Material** Examine each window frame to determine and record the type of material used. Visually confirm whether the frame is made of metal, wood or vinyl. Alternatively, confirm by examining the window for a descriptive label or review the product manufacturer's data sheet. Where a metal framed dual- or multiple-paned window is installed, determine and record if a thermal break is present by looking for two separated metal extrusions connected by a rubber spacer. Alternatively, confirm by reviewing the product manufacturer's data sheet. Determine and record and record the window cladding type. Check both the inside and outside since some windows will have cladding on one side only. **Glazing Type** Determine and record whether the windows are single-paned, double-paned or multiple-paned. Determine and record and record whether Glazing has a tint or low-e coating.

Orientation	Determine and record orientation of all windows.	Determine and record orientation of all windows and record orientation to the nearest cardinal/ordinal points. When using a compass while standing in front of a window inside the Dwelling Unit, record orientation while facing the exterior. When using a compass while standing outside the Dwelling Unit, record orientation while standing with back to the window.
External Shading	Determine and record permanent, fixed shading of windows.	Identify permanent, fixed shading devices attached to the building. Fins and overhangs shall be considered fixed shading devices. Window screens, security bars, balcony railings, movable awnings, roller shades, and shade from adjacent buildings, trees and shrubs shall not be considered fixed shading devices. **Projections and Overhangs** The shading impact of a projection or overhang is found by measuring the length of the overhang from the exterior wall surface, the distance between the top of the window and the bottom edge of the overhang, and the distance between the bottom of the window and the bottom edge of the overhang. Measure the length of the overhangs over each exterior wall to the nearest inch. Measure the distance between both the top of the window and the bottom of the window to the bottom edge of the overhang, to the nearest inch.
Solar heat gain coefficient	Determine and record solar heat gain coefficient of Glazing.	Look for a National Fenestration Rating Council (NFRC) label on new windows. It will display Solar Heat Gain Coefficient (SHGC). Where no label is found, identify window in NFRC Certified Products Directory to determine and record SHGC or consult manufacturer's data sheet. If no SHGC is identified from window label, product literature or NFRC directory, use the known window characteristics to select the SHGC from Table 10 in the ASHRAE *Handbook of Fundamentals*, Chapter 5, *or*, LBL *RESFEN 6.0 User Manual*, Table 5.5, or Efficient Window Collaborative window selection tool.

U-value	Determine and record window U-value.	Look for an NFRC label on new window. It will display full window U-value. Where no label is found, identify window in NFRC Certified Products Directory to determine and record U-value or consult manufacturer's data sheet. If no U-value is identified from window label, product literature or NFRC directory, use the known window characteristics to select the U-value from Table 4 in ASHRAE *Handbook of Fundamentals*, Chapter 5 or LBL *RESFEN 6.0 User Manual*, Table 5.5, or Efficient Window Collaborative window selection tool.
Natural Ventilation	Determine and record whether or not there are operable windows in the Dwelling Unit.	Inspect all windows located in the Dwelling Unit and document which are operable and which are not.

Building Element: Skylights		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Area	Determine and record area of skylights.	See Table "Building Element: Windows."
Construction type	Determine and record framing and Glazing characteristics of skylights.	See windows.
Orientation	Determine and record orientation of skylights.	Determine and record the orientation of the lower edge of the skylight. Use this direction as the orientation of the skylight.
Shading	Determine and record shading of skylights.	See windows.
Solar heat gain coefficient	Determine and record solar heat gain coefficient of skylights.	See windows.
U-value	Determine and record skylight U-value.	See windows.
Tilt	Determine and record tilt of skylights.	Measure the tilt of the skylight relative to horizontal. This may be done with a level and angle finder instrument or geometrically with a protractor. If the pitch of the roof is known or can be measured and if the skylight is in line with the roof, then the roof pitch may also be considered the tilt of the skylights.

Building Element: Passive Solar System		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Direct gain	Identify system type and determine and record solar aperture orientation and aperture area	Through proper sizing, placement, orientation, and/or control of windows, skylights, shading devices and solar storage mass within the building, a solar direct gain system is designed to reduce heating, cooling, and lighting energy requirements. To determine and record aperture area, measure width and height of south-facing Glazing in the northern hemisphere and the north-facing Glazing in the southern hemisphere and indicate tilt angle. Record glass type(s) and presence of night insulation, when present. Determine and record orientation to the nearest cardinal/ordinal point. Determine and record the type of thermal mass, its thickness and its dimensions. Determine and record whether the mass will be lit by direct solar rays between the hours of 9:00 a.m. and 3:00 p.m. during the heating season. Record any trees or other obstructions to solar gain.
Greenhouse or solarium	Identify system type and determine and record solar aperture orientation, aperture area and information about thermal mass	A greenhouse or solarium creates a South-glazed buffer zone in the northern hemisphere and a North-glazed buffer zone in the southern hemisphere between the Dwelling Unit and the exterior to help heat the living area. See Direct gain, above, for specific inspection items.
Thermal storage mass	Identify system type and determine and record solar aperture orientation, aperture area, and information about thermal mass	Thermal mass systems consist of solar-exposed heavyweight materials with high heat capacitance and relatively high conductance or high thermal diffusivity that are placed in the same zones(s) as the solar collection area(s). (within the building envelope). Determine and record whether these elements are integral with the building or distinct elements within the building. The thermal mass system must have direct access to the solar aperture that is within 15 degrees of true south. **Distinct components:**

Building Element: Passive Solar System		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		Trombe wall - uses a heat storage mass placed between the glass and the space to be heated. Measure area of storage mass, determine and record material, thickness, and capacitance. *Water wall* - replaces the existing wall, or parts of it, with containers that hold water.
Thermosiphon Air Panel (TAP)	Identify system type	*Thermosiphon air panel (TAP)* - has one or more Glazing layers made of glass or plastic, an air space, an absorber, another air space and (often) an insulated backing. These are similar in appearance to active flat-plate collectors, often mounted vertically on walls or ground-mounted so that the living space is higher than the collector to facilitate convection from the TAP to the building. See Greenhouse, above, for specific inspection items.

Building Element: Air Leakage		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Blower door test	Determine and record airtightness from a blower door test	Follow Procedure for Measuring Airtightness of Building or Dwelling Unit Enclosure in ANSI/RESNET/ICC 380.
Infiltration Volume	Determine and record Infiltration Volume of Rated Home	Determine and record the Infiltration Volume in accordance with the definitions. See examples of common Infiltration Volumes in Informative Annex A in ANSI/RESNET/ICC 380
Compartmentalization Boundary	Determine and record Compartmentalization Boundary	Determine and record the Compartmentalization Boundary by calculating the surface area that bounds the Infiltration Volume.

Building Element: Heating and Cooling Distribution System		
Rated Feature	**Task**	**On-Site Inspection Protocol**
System type	Identify type of distribution system used to provide space heating and cooling	*Forced air* - a fan unit or air handler connected to ducts that supply heated or cooled air to multiple rooms in the Dwelling Unit. Forced air systems have supply or return ductwork. *Unit heater/Air Conditioner* - heating or cooling is supplied directly from a heating or cooling device located within the space it serves. Unit heater/Air Conditioner equipment has no supply or return ductwork.[115] *Forced hot water* - heated water is pumped through a series of radiator elements to supply heat. Identify and record the radiator elements as conventional radiators, baseboard "fin tube" radiators, cast iron baseboards or radiant hot water panels located at the baseboards or on walls or ceilings. *Hot water radiant system* - heated water is circulated through plastic or metal tubing that is installed in a concrete slab or finished floor or occasionally, in walls or ceilings. *Steam heating* - steam systems utilize a distribution system with cast iron radiators connected to a Boiler that creates steam. The steam rises into the radiators through one set of pipes, condenses into water and drains back to the Boiler. There are 2 common system types: One Pipe Steam - Radiators have only one pipe connected with a shutoff valve. There will also be an air vent on the opposite end of the radiator from the pipe connection. Two Pipe Steam - Radiators will have a larger steam supply pipe and a smaller condensate return pipe. There will be a control valve on the steam side and a steam trap on the condensate side.

[71] (Informative Note) Examples of unit heater / Air Conditioner equipment include window Air Conditioner s, package terminal heat pumps (PTHP), packaged terminal Air Conditioner (PTAC), and ductless minisplits. Where unit heater / Air Conditioner equipment has any amount of ductwork, they are forced air systems.

Building Element: Heating and Cooling Distribution System		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		Electric radiant system - Electric cables are installed in concrete floor slabs or in the ceiling. Electric current is passed through the cables, causing them to heat up, heating the floor, individual radiant wall panels or the ceiling assembly, which radiates heat to the space. *Baseboard electric resistance* - Electric elements are installed in baseboard enclosures. Electric current is passed through the electric element to provide heat to the space. *Electric unit heaters* - Electric elements are enclosed in a cabinet with a blower that is suspended from the ceiling or mounted in a ceiling cavity, wall cavity, under a kitchen or bath cabinet (kickplate) or other areas. In multifamily buildings, look for these units in stairwells, storage rooms, mechanical rooms, water meter closets or any space with a small or low heating load.
Location of air ducts	Determine and record the location of ducts	Locate and differentiate between supply and return ducts. The location of air ducts shall be recorded as in attic space, crawlspace, basement or other conditioned or unconditioned space. Use the definitions in Section 3 to classify the locations as Infiltration Volume, Conditioned Space Volume, Unconditioned Space Volume or Unrated Conditioned Space. Approximate the percentage and square foot surface area of both the supply and return ductwork in each area when supply/return ducts are located in more than one area.
Insulation	Determine and record the R-Value of distribution system insulation	Inspect the ducts or pipes to confirm they are insulated and look for labeling printed on the insulation by the manufacturer. Record R-Value. Where insulation is not marked with the R-Value, identify type and measure the thickness of the insulation to determine and record R-Value.
Leakage of air ducts	Determine and record air leakage from ducts	Use default estimates as applicable in Table 4.2.2(1) or follow Procedure for Measuring Airtightness of Duct Systems in ANSI/RESNET/ICC 380.

Building Element: Heating and Cooling Distribution System		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Circulation pumps	Determine and record the energy use of the distribution pumps	Record the horsepower and model number of any primary and secondary pumps associated with the distribution circulation loop, excluding any pumps on standby. Use the model number of the pumps to determine and record the pump motor efficiency from the manufacturer's data sheet. The number of Dwelling Units served by the circulation loop shall also be determined.

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Equipment class	Identify Class of equipment for heating and/or cooling	*Individual* - standalone equipment serving a single Dwelling Unit, often located within the Dwelling Unit. These units heat or cool the space and, other than electric connections to power the fans, controls or compressors, are not connected to circulating fluids from a central Boiler or Chiller. *Terminal* - In-Dwelling Unit equipment that heats and cools the space and is connected to Boilers, Chillers, Variable Refrigerant Flow Multi-Split Air Conditioning and Heat Pump Equipment or Cooling Towers. Fan coils and Water Loop Heat Pumps often indicate the use of a remote central Boiler or Chiller. However, some terminal equipment appears similar to individual equipment and yet relies on a remote energy source to function. Look for insulated water pipes, refrigerant tubing, or control valves. Confirm that there is no in-unit heating or cooling equipment or equipment in adjacent spaces that solely serves the terminal equipment of the Dwelling Unit that may be outside of the Dwelling Unit. *Central* - larger heating or cooling equipment that serves more than one Dwelling Unit and possibly common spaces using a conveyance to deliver and receive a circulating energy transfer medium to heat or cool the Dwelling Units through their terminal equipment. The circulation conveyance may be water piping or refrigerant tubing and likely will be insulated. Water loops will have circulating pumps. See Central Equipment below for details.
Location	Determine and record the location of heating and cooling equipment	Record whether individual, terminal and central systems are in Conditioned Space Volume, Unrated Conditioned Space, Unrated Heated Space or Unconditioned Space Volume.
Control system	Identify the control system for the heating and cooling system(s)	Determine and record the type of control systems and look for separate controls for the heating and cooling systems.

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		Determine and record whether the Dwelling Unit thermostat controls are programmable, understanding that not all digital thermostats are programmable.
Efficiency	Determine and record the heating and cooling equipment efficiency and capacity	Look for the equipment nameplates and product literature. Record the manufacturer and model number, capacity and, if listed directly on the nameplate, the efficiency rating. If not listed, use the model number to identify the efficiency rating in the AHRI directory. Where the nameplate information is not available or not accessible, use manufacturer's data sheet, equipment directories or age-based defaults from Section 4.5.2 to determine and record an appropriate efficiency. SEER is used to measure the cooling efficiency of central air conditioning and Air Source Heat Pump systems. EER is used to determine and record the cooling efficiency of room Air Conditioners, VRF, Water Loop Heat Pumps and Ground Source Heat Pumps. EER can be calculated from the nameplate information by dividing Btu output by Watt input. Chillers are rated in kW/ton. HSPF or COP is used to measure the heating efficiency of Air Source Heat Pumps, VRF, Water Loop Heat Pumps, and Ground Source Heat Pumps. AFUE or Thermal Efficiency is used to measure the efficiency of Furnaces and Boilers.
Heating and cooling energy source	Determine and record fuels used for heating and cooling	Heating systems use natural gas, propane, oil, electricity, or some other fuel. Most cooling systems are driven by electricity; however, some cooling equipment use natural gas or propane.

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Individual Heating and Cooling Equipment	Identify type(s) of individual equipment for heating and cooling of a single Dwelling Unit	Determine and record the individual heating/cooling type that is present in each Dwelling Unit. Typical unit types are defined below: *Boiler* – creates hot water or steam, powered by any fuel type and can be used with forced air distribution in conjunction with a fan coil unit or PTAC where the fan blows air over the hot water coil to provide heating, or distributed by forced hot water, steam or a hot water radiant slab system. *Direct evaporative cooler* - used primarily in very dry climates. Evaporative coolers work by blowing air over a damp pad or by spraying a fine mist of water into the air. Direct evaporative coolers add moisture to the home. *Furnace* - comprised of a combustion chamber and heat exchanger or an electric resistance element and a fan that forces air across the heat exchanger or resistance element to provide heat in a forced air system. *Ground Source Heat Pumps* - are coupled to the ground through the use of a water well. Determine and record if a closed or open loop system is present. In Attached Dwelling Units, confirm and record when a circulation loop is shared amongst multiple Dwelling Units. See Central Equipment below for details. *Packaged terminal* Air Conditioner *(PTAC)* - a factory-selected wall sleeve and separate un-encased combination of heating and cooling components, assemblies, or sections. It may include heating capability by hot water, steam or electricity and is intended for mounting through the wall to serve a single room or zone. If a hot water coil is present, determine and record if the Boiler is individual or central. *Packaged terminal Heat Pump (PTHP)* - a PTAC capable of using the refrigerating system in a reverse cycle or Heat Pump mode to provide heat.

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		Split system Air Source Heat Pump - move energy from one location to another using the vapor-compression cycle. They are electrically driven and provide heating in winter and cooling in summer by reversing the direction of heat flow. Split system Heat Pumps consist of an outdoor unit and an indoor air handling unit, resembling a Furnace. These systems require ductwork for air distribution. Most Air Source Heat Pumps incorporate electric resistance supplemental heat in the indoor section. However, some Heat Pump systems use a fossil fuel Furnace for supplemental heating. These are known as "dual fuel" or add-on systems. *Split system* Air Conditioner - similar to a split system Air Source Heat Pump. Consists of an outdoor unit and a coil in the forced air distribution system. These systems are electrically powered and provide cooling. *Through-the-wall ductless Air Source Heat Pump* - a single packaged Air Source Heat Pump installed without a distribution system. Provides both heating and cooling and is installed through an exterior wall. *Unit space heater* - fossil fuel burning heaters that have individual controls and no distribution system. Determine and record when the system is equipped with a fan for forcing air circulation over a heat exchanger or uses simple convective forces. These heaters are mounted on outside walls to facilitate venting and use natural gas, kerosene, propane or other types of fossil fuel. *Variable-speed Mini-Split and Multi-Split Heat Pumps* – systems listed under "residential" in the AHRI Directory and have multiple configurations depending on whether the system is "single-port" or "multi-port" and whether

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		it is ducted, nonducted or a mix. They are considered individual systems when they serve only one Dwelling Unit.[116] *Window/through-the-wall Air Conditioner* – a single packaged ductless Air Conditioner designed to be installed without a distribution system and without a factory-selected sleeve. *Electric resistance heater* – electric heaters that typically have individual controls and no distribution system. They are typically either electric baseboard heaters, electric wall heaters or electric bathroom heaters.

[72] (Informative Note) The term "mini-split" generally refers to a nonducted, "single-port" Heat Pump.

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Terminal Heating and Cooling Equipment	Identify type(s) of terminal equipment served by centralized systems for heating and cooling in each Dwelling Unit	Determine and record the terminal heating/cooling type that is present in each Dwelling Unit. Typical terminal unit types are defined below: *Fan coil unit* – hot/chilled water from a central Boiler /Chiller is circulated through a coil. A fan blows air over the coil to provide heating/cooling. *Hot Water Packaged Terminal Air Conditioner (HW PTAC)* – A PTAC that includes a hot water coil connected to a central Boiler. *Hydronic/radiant or convectors* – hot water from a central Boiler is pumped through a series of radiator elements to supply heat. Conventional radiator elements are radiators, baseboard "fin tube" radiators, cast iron baseboards, or radiant hot water panels located at the baseboards or on the walls or ceilings. *Variable Refrigerant Flow Multi-Split Air Conditioning and Heat Pump terminal units* – refrigerant flows at a variable rate from one or more central outdoor units to indoor units located in the Dwelling Units. Styles of VRF terminal units include wall mounted, ceiling cassette, ceiling suspended, and are either ducted, nonducted, or mixed. *Water Loop Heat Pumps* – hot/cold water from a centralized Boiler and Cooling Tower is circulated through a Heat Pump in each Dwelling Unit.

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Central Heating and Cooling Equipment	Identify type(s) of central equipment serving terminal units in each Dwelling Unit	*Absorption cooler* – a gas Air Conditioner. Look for a Cooling Tower, an exhaust pipe, a gas burner to evaporate refrigerant and a heat exchanger similar to an electric Air Conditioner. *Boiler* – device which creates hot water or steam, may be powered by any fuel type and can be used with forced air distribution, in conjunction with a fan coil unit or PTAC where the fan blows air over the hot water coil to provide heating, or distributed by forced hot water, steam or a hot water radiant slab system. Record whether the Boiler also provides service hot water. *Chiller* –vapor-compression cooling equipment that uses the outdoor air or water circulated through a Cooling Tower as a heat sink for cooling and absorbs heat from conditioned space by means of a hydronic cold water distribution system. Determine and record whether the Chiller is a DX Chiller, water-cooled, or absorption. *Cooling Tower* – heat rejection device that rejects heat to the atmosphere. Record the fan horsepower from the nameplate data of the Cooling Tower fan located inside the Cooling Tower. Record the horsepower and model number of the sprayer pump located inside the Cooling Tower. Alternatively, record the model number from the nameplate data of the Cooling Tower to determine and record the fan and sprayer pump data from manufacturer's data sheet. *Ground Source Heat Pump* – shared vapor-compression heating and cooling equipment that uses the ground or ground water as the heat source or sink for heat. *Rooftop Make-Up Air Unit (MAU) or Dedicated Outdoor Air System (DOAS)* – large rooftop equipment that provides outdoor air or make-up air, with or without heating or cooling. In multifamily buildings, these systems may provide ducted air directly to the Dwelling Units or to other common spaces.

Building Element: Heating and Cooling Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		Single packaged Air Conditioner – similar to single packaged Air Source Heat Pumps. These systems provide cooling only. In multifamily buildings, these systems may provide ducted air directly to the Dwelling Units or to other common spaces. *Single package Air Source Heat Pump* – a single package Heat Pump is similar to a split system except it combines the functions of the indoor and outdoor units into one cabinet, mounted on the roof or on the ground. In multifamily buildings, these systems may provide ducted air directly to the Dwelling Units or to other common spaces. *Variable Refrigerant Flow Multi-Split Air Conditioning and Heat Pump outdoor units* – refrigerant flows at a variable rate from one or more central outdoor condensing units to evaporator units located in the Dwelling Units.

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
For Evaluation of Design Information:		
Completeness of all required HVAC design documentation	Collect HVAC design documentation and verify that all required design elements have been provided	Collect HVAC design documentation and verify that all required design elements, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310, have been provided.
Compliance with design criteria	Evaluate HVAC design documentation	Evaluate whether the collected HVAC design documentation complies with the design criteria prescribed in Standard ANSI/RESNET/ACCA/ICC 310, relative to the Dwelling to be rated.
For Total Duct Leakage Installation Quality:		
Total duct leakage	Determine and record total air leakage from ducts	As prescribed in Standard ANSI/RESNET/ACCA/ICC 310, follow Procedure for Measuring Airtightness of Duct Systems in Standard ANSI/RESNET/ICC

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		380.[117]
Conditioned Floor Area served by the system	Calculate the Conditioned Floor Area that the HVAC system serves	Calculate the Conditioned Floor Area that the HVAC system serves.
Number of returns	Count the number of returns	Count the number of returns, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Whether tested at rough-in or final	Identify whether the total duct leakage was tested at rough-in or final	Identify whether the total duct leakage was tested at rough-in or final, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Total duct leakage grade	Designate total duct leakage grade	Designate the total duct leakage grade (Grade I, II, or III), as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Confirmation that total supply distribution system ≤ 10 ft. and entirely in Conditioned Space Volume	Assess whether the total supply distribution system ≤ 10 ft. and entirely in Conditioned Space Volume	If using the exception to not test total duct leakage, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310, then visually verify that the total amount of supply ductwork or distribution building cavities does not exceed 10 ft. in length and is entirely in Conditioned Space Volume.
For Blower Fan Volumetric Airflow Installation Quality:		
Test method selection	Select the test method	Select the test method to assess Blower Fan volumetric airflow, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310 – either the Pressure Matching Method, a Flow Grid, a Flow Hood, or the OEM Static Pressure Table Method.
Test mode	Determine and record the mode to conduct the test in	Determine and record the mode to conduct the test in, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310 – either cooling or heating mode.

[117] (Informative Note) This minimum rated feature may be determined and recorded as part of the heating and cooling system building element.

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Blower Fan volumetric airflow	Determine and record Blower Fan volumetric airflow	Measure the Blower Fan volumetric airflow, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Design-specified Blower Fan volumetric airflow	Identify the design-specified Blower Fan volumetric airflow.	Identify the design-specified Blower Fan volumetric airflow, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310. This value is reported in the HVAC design documentation
Blower Fan volumetric airflow grade	Designate Blower Fan volumetric airflow grade	Designate the Blower Fan volumetric airflow grade (Grade I, II, or III), as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Supply-side static pressure during normal operation (Psop)	Determine and record Psop	If using the Pressure Matching Method or a Flow Grid, then measure Psop, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Supply-side static pressure during test (Ptest)	Determine and record Ptest	If using the Pressure Matching Method or a Flow Grid, then measure Ptest, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Average measured airflow during test (Qtest)	Determine and record Qtest	If using the Pressure Matching Method or a Flow Grid, then measure Qtest, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Fan Flowmeter connection location	Determine and record the Fan Flowmeter connection location	If using the Pressure Matching Method, then determine and record whether the Fan Flowmeter will be connected to the system, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310 – either at a return grille or at the blower compartment.
Blower Fan motor type	Determine and record Blower Fan motor type	If using the OEM Static Pressure Table method, then determine and record the Blower Fan motor type, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310. This value is reported in the HVAC design documentation.

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Blower Fan fan-speed setting	Assess Blower-Fan fan-speed setting	If using the OEM Static Pressure Table method, then assess the Blower-Fan fan-speed setting, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Total Operational System Pressure (Ptop)	Measure Ptop	If using the OEM Static Pressure Table method, then measure Ptop, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Filter pressure adjustment factor (Pfilter)	Determine and record Pfilter	If using the OEM Static Pressure Table method, then determine and record Pfilter, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Elevation above sea level	Determine and record elevation above sea level	If using the OEM Static Pressure Table method, then determine and record the elevation above sea level of the Dwelling to be rated.
Whether turbulent conditions were encountered	Assess whether turbulent conditions were encountered	If using the Pressure Matching Method, a Flow Grid, or the OEM Static Pressure Table method, then assess whether turbulent conditions were encountered, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Confirmation that total supply distribution system ≤ 10 ft. and entirely in Conditioned Space Volume	Assess whether the total supply distribution system ≤ 10 ft. and entirely in Conditioned Space Volume	If using the exception to not test total Blower Fan volumetric airflow, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310, then visually verify that the total amount of supply ductwork or distribution building cavities does not exceed 10 ft. in length and is entirely in Conditioned Space Volume.
For Blower Fan Watt Draw Installation Quality:		
Test method selection	Select the test method	Select the test method to assess Blower Fan watt draw, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310 – either a portable plug-in watt meter, clamp-on watt meter, analog utility revenue meter, or digital utility revenue meter.

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Test mode	Determine and record the mode to conduct the test in	Determine and record the mode to conduct the test in, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310 – either cooling or heating mode.
Blower Fan watt draw	Determine and record Blower Fan watt draw	Measure the Blower Fan watt draw, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Blower Fan volumetric airflow	Determine and record Blower Fan volumetric airflow	Determine and record Blower Fan volumetric airflow, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Blower Fan watt draw grade	Determine and record the Blower Fan watt draw grade	Determine and record Blower Fan watt draw grade (Grade I, II, or III), as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Kh factor of analog utility revenue meter	Determine and record the Kh factor of the analog utility revenue meter	If using the analog utility revenue meter method, then visually determine and record the Kh factor of the meter, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Number of meter wheel revolutions	Determine and record the number of meter wheel revolutions	If using the analog utility revenue meter method, then count the number of the meter wheel revolutions (Nrev) during the test, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Duration of test	Determine and record the duration of the test	If using the analog utility revenue meter method, then measure the duration of the test (Trev), as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
For Refrigerant Charge Installation Quality:		
Test method selection	Select the test method	Select the test method to assess refrigerant charge, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310 – either the non-invasive method or the weigh-in method.
Refrigerant charge grade	Determine and record refrigerant charge grade	Determine and record refrigerant charge grade (Grade I or III) as prescribed in Standard ANSI/RESNET/ACCA/ICC 310
Rated SEER value	Determine and record rated SEER value	If using the non-invasive method, then determine and record the SEER rating of the Air Conditioner or Heat Pump, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310. This value is reported in the HVAC design documentation.

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Design-specified Blower Fan volumetric airflow in cooling mode	Determine and record the design-specified Blower Fan volumetric airflow in cooling mode	If using the non-invasive method, the determine and record the design-specified Blower Fan volumetric airflow of the Air Conditioner or Heat Pump in cooling mode, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310. This value is reported in the HVAC design documentation.
Design maximum total heat gain	Determine and record the design maximum total heat gain	If using the non-invasive method, then determine and record the design maximum total heat gain, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310. This value is reported in the HVAC design documentation.
Metering device type	Determine and record the type of metering device	If the non-invasive method is used, determine and record the type of metering device on the Air Conditioner or Heat Pump, either piston or capillary tube, Thermal Expansion Value (TXV), or Electronic Expansion Valve (EEV), as prescribed in Standard ANSI/RESNET/ACCA/ICC 310. This value is reported in the HVAC design documentation.
Target subcooling value	Determine and record the target subcooling value	If the non-invasive method is used and the metering device type is TXV or EEV, determine and record the target subcooling value, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310. This value is reported in the HVAC design documentation.
Target superheat value	Determine and record the target superheat value	If the non-invasive method is used and the metering device type is piston or capillary tube, determine and record the target superheat value, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Return air dry-bulb temperature	Determine and record the return air dry-bulb temperature	If the non-invasive method is used, measure the return air dry-bulb temperature, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Return air wet-bulb temperature	Determine and record the return air wet-bulb temperature	If the non-invasive method is used, measure the return air wet-bulb temperature, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Outdoor air dry-bulb temperature	Determine and record the outdoor air dry-bulb temperature	If the non-invasive method is used, measure the outdoor air dry-bulb temperature, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Suction line Temperature	Determine and record the suction line temperature	If the non-invasive method is used, measure the suction line temperature, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Liquid line Temperature	Determine and record the liquid line temperature	If the non-invasive method is used, measure the liquid line temperature, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Documentation of any site-specific installation values from installing contractor	Document any site-specific installation values from the installing contractor	If the non-invasive method is used, then document any site-specific installation values provided by the installing contractor, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Required refrigerant system documentation	Collect refrigerant system documentation and verify that all required elements have been provided	If the weigh-in method is used, collect the refrigerant system documentation and verify that all required elements, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310, have been provided including: total reported weight of refrigerant added or removed, an indication of whether the refrigerant was added or was removed, an indication of whether the factory-supplied refrigerant was first removed, and one or more time-stamped and geotagged photographs showing the scale displaying the total weight of refrigerant added or removed from the system.
Total length of the liquid line	Determine and record the total length of the liquid line	If the weigh-in method is used, determine and record the total length of the liquid line, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Outside diameter of the liquid line	Determine and record the outside diameter of the liquid line	If the weigh-in method is used, measure the outside diameter of the liquid line, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Weight of the refrigerant required	Determine and record the weight of the refrigerant required for the	If the weigh-in method is used, determine and record the weight of the refrigerant required for the incremental liquid line length, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.

Building Element: Air Conditioner, Furnace, and Heat Pump Installation Quality Grade		
Rated Feature	**Task**	**On-Site Inspection Protocol**
for the incremental liquid line length	incremental liquid line length	
Total anticipated weight of refrigerant	Determine and record the total anticipated weight of refrigerant	If the weigh-in method is used, determine and record the total anticipated weight of refrigerant, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Total reported refrigerant weight	Determine and record the total reported weight of refrigerant	If the weigh-in method is used, determine and record the total reported weight of refrigerant, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Deviation in total refrigerant weight	Determine and record the deviation in total refrigerant weight	If the weigh-in method is used, determine and record the deviation in total refrigerant weight, as prescribed in Standard ANSI/RESNET/ACCA/ICC 310.
Evaluation of geotagged photo(s)	Evaluate the geotagged photo(s)	If the weigh-in method is used, evaluate whether the geotagged photo(s) collected as part of the refrigerant system documentation complies with the criteria prescribed in Standard ANSI/RESNET/ACCA/ICC 310.

Building Element: Service Hot Water (SHW) Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Equipment class	Identify class of equipment for Service Hot Water (SHW)	*Individual* - standalone service hot water system serving a single Dwelling Unit. *Central* - shared service hot water system serving more than one Dwelling Unit. These shared systems may also provide service hot water to common spaces and shared laundry rooms. *Laundry* - service hot water system providing hot water for shared clothes washers that does not provide other service hot water to the Dwelling Unit.
Location	Determine and record location of service hot water equipment	Determine and record whether the water heater is in Conditioned or Unconditioned Space Volume, Unrated Heated Space or Unrated Conditioned Space.
Efficiency	Determine and record the Energy Factor, Uniform Energy Factor or thermal efficiency of the service hot water equipment	Look for the water heater's nameplate and product literature. Record the manufacturer, model number and if listed directly on the nameplate, the efficiency rating. Search for the model number in the manufacturer's data sheets or appropriate efficiency rating directory to determine and record the EF, UEF or thermal efficiency rating. When UEF is recorded, also record the First Hour Rating. When thermal efficiency is recorded, also record the standby loss if available. When the efficiency rating cannot be determined, approximate the age of the unit and use a default efficiency.
Extra tank insulation value	Determine and record the insulation value of any exterior wrap	Visually determine and record whether the water heater is or is not wrapped with exterior insulation. When insulation is present, look for the labeled/stamped R-value or measure the thickness of the wrap and determine and record the R-Value.
Individual service hot water equipment type	Determine and record type, capacity, and fuel source of standalone water heater serving single Dwelling Unit	Identify whether the equipment is storage or instantaneous, identify its fuel source and record storage tank capacity in gallons. Also record whether the SHW equipment is supplemented by a desuperheater and/or if it is integrated with the space heating system.

Building Element: Service Hot Water (SHW) Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		.
Central service hot water equipment type	Determine and record type, capacity, fuel source and pump power of shared service hot water equipment serving more than one Dwelling Unit	Identify if equipment is: a Boiler or water heater, residential or commercial grade; its fuel source; and pump power. Record storage tank capacity in gallons. Also record whether the SHW equipment is integrated with the space heating system and how many Dwelling Units it serves. *Central Boiler with indirect fired storage tanks* – Record the number of Boilers and tanks. Record the fuel source and the model number, capacity and insulation value, when present, of the unfired storage tanks. *Central service hot water heater* – Record the number of water heaters, the fuel source, capacity and insulation value when present. *Central pump power* - In addition, record the horsepower and model number of all primary and secondary pumps that are associated with the service hot water distribution loop, excluding any pumps on standby. If not listed on the nameplate, use the pump model number to determine the pump motor efficiency from the manufacturer's data sheet.
Laundry service hot water equipment type	Determine and record type, capacity, and fuel source of laundry SHW equipment	Where a separate service hot water system provides hot water to clothes washers, but does not provide other service hot water to the Dwelling Unit, follow guidance for individual service hot water systems above to identify system type, capacity, and fuel source.
Drain Water Heat Recovery (DWHR)	Determine and record efficiency and performance factors	Where DWHR units are installed and serve the Rated Home, record the model number of the DWHR unit, its efficiency and the number of showers in the Rated Home that are connected to the unit. A performance factor shall be determined and recorded based on its installation location. Determine and record if the DWHR unit supplies pre-heated water to the cold water piping, hot water heater potable supply piping or to both.

Building Element: Service Hot Water Distribution		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Hot water pipe length	Determine and record hot water distribution pipe length	The hot water distribution pipe length from the water heater to the farthest hot water fixture shall be measured longitudinally, 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). For Dwelling Units being served by a Central SHW with a recirculation loop, begin the pipe length measurement from the shared recirculation loop rather than the water heater.
Pipe insulation	Determine and record R-Value of pipe insulation	Inspect the hot water piping to determine if the piping is insulated. Measure the thickness of the insulation and identify material to determine and record if its R-Value is at least R-3. If the pipe insulation is ≥ R-3, record that the Rated Home has at least R-3 pipe insulation and model it accordingly. If the pipe insulation is < R-3, record that the Rated Home does not have R-3 pipe insulation and model it accordingly.
Recirculation system	Determine and record the hot water recirculation type, control strategy and branch length	Inspect the hot water distribution system to determine and record whether the system is a standard system or a recirculation system. When a recirculation system is entirely within the Rated Home or serves more than one Attached Dwelling Unit, then the control strategy shall be documented as one of the following strategies. *Uncontrolled* – The pump runs continuously. *Timer*– The pump is controlled by a timer. *Temperature control* – The pump runs based on monitoring temperature at some point in the system. *Demand (presence sensor)* – The pump only runs when a sensor detects someone is present at the faucet.

		Demand (manual) – The pump only runs when a user presses a button indicating they are about to use hot water. When a recirculation system is entirely within the Rated Home, the branch hot water pipe length from the recirculation loop to the farthest hot water fixture from the recirculation loop shall be measured longitudinally, assuming the branch hot water piping does not run diagonally.
Flow rates of Bathroom sink faucets and showerheads	Determine and record gpm of Bathroom sink faucets and showerheads	Determine and record the rated gpm printed on all showerheads and Bathroom sink faucets. When the gpm rate is not visible, collect documentation showing the model number of the plumbing fixtures and use manufacturer's data sheet to determine and record the rated gpm. If all Bathroom sink faucets and showerheads in the Rated Home are ≤ 2.0 gpm, record that the Rated Home has low-flow faucets and showerheads and model it accordingly. A shower with multiple showerheads that operate simultaneously meets the low-flow criteria if the sum of the flow rate of all showerheads sums to ≤ 2.0 gpm. If any or all Bathroom sink faucets and showerheads in the Rated Home are > 2.0 gpm, record that the Rated Home has standard faucets and showerheads and model it accordingly.

Building element: Solar Domestic Hot Water Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
System type	Determine and record type of solar systems	Determine and record whether a solar domestic hot water system exists. These systems collect and store solar thermal energy for domestic water heating applications. When a solar water heating system exists, determine and record system type. For systems manufactured after January 1, 1995, system type, Energy Factor (EF), and other performance characteristics shall be determined from the SRCC label and by referring to SRCC literature. For systems lacking an SRCC label, Energy Factor and other performance characteristics are determined using a certified energy modeling tool or appropriate default values. Identify as passive or active. Base your evaluation on these criteria: *Passive* - No purchased electrical energy is required for recirculating water through a passive solar collector. Three types of passive systems are integrated collector storage (ICS), thermosiphon systems and self-pumped systems. *Integrated Collector Storage (ICS)* - consists of a single unit that incorporates both collector and water storage.[118] *Thermosiphon* - consists of a flat-plate solar collector and hot water storage tank. Instead of using a pump, circulation of the fluid is achieved by natural convection action. The storage tank must be located above the collector and can be inside or outside the Conditioned Space Volume. *Self-pumped* - circulates fluid from storage to collectors without purchased electrical energy. Photovoltaic and percolating systems are self-pumped systems. The storage tank can be inside or outside the Conditioned Space Volume. *Active* -Also known as pumped systems.

[73] (Informative Note) An example is the common "bread box" design. Storage is usually outside the Conditioned Space Volume.

Building element: Solar Domestic Hot Water Equipment		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		Pumped -purchased electrical energy input is required for operation of pumps or other components. The storage tank can be inside or outside the Conditioned Space Volume.
Solar collector type	Identify type of solar collector	Identify the type of solar collector by checking for the SRCC label or manufacturer's data sheet.
Collector details	Determine and record area, orientation, and tilt of collector	Determine and record the area of the collector. Determine and record the orientation of the solar collector to the nearest cardinal/ordinal point in the direction toward which the collector faces. To determine and record the tilt of the collector, use either geometric calculations based on horizontal length and vertical height measurements or a site selection and angle finder instrument.
Efficiency	Determine and record efficiency of solar system	Search for SRCC label. Check for SRCC system and component nameplates. Refer to the Directory of SRCC Certified Solar Collector and Water Heating System Ratings, or other SRCC literature for Energy Factor (EF) and other performance data.
Storage tank size and location	Determine and record the capacity of the storage tank and location	To determine and record the size of the storage tank, refer to documentation or a label indicating the tank capacity. Determine and record and record whether the storage tank is in Conditioned or Unconditioned Space Volume, Unrated Heated Space or Unrated Conditioned Space.
Extra tank insulation value	Determine and record the insulation value of any exterior wrap	See Service Hot Water, above.
Pipe insulation value	Determine and record the insulation value of the pipes	Determine and record the R-Value of insulation installed on pipes.

Building Element: Light Fixtures		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Number of Qualifying and non-qualifying Light Fixtures	Calculate percentage of Qualifying Light Fixtures by dividing the part by the whole	For each of the three categories of lighting locations (i.e., Interior, Exterior and Garage), record whether the Qualifying Light Fixtures are or are not installed at the time of the inspection. If the Qualifying Light Fixtures are installed at the time inspection, then determine and record if they are Tier I or Tier II. For each of the three categories of lighting locations (i.e., Interior, Exterior, and Garage), record the ratio of Qualifying Tier I Light Fixtures to all light fixtures in Qualifying Light Fixture Locations and the ratio of Qualifying Tier II Light Fixtures to all light fixtures in Qualifying Light Fixture Locations. This ratio is calculated by fixture and not by light bulb.

Building Element: Refrigerator(s)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Total annual consumption of refrigerator	Determine and record total annual consumption of refrigerator	Record whether the refrigerator is or is not installed at the time of the inspection. If the refrigerator is installed at the time of inspection, then record the model number of the refrigerator and determine and record the total annual consumption from either the refrigerator Energy Guide Label, the California Energy Commission Appliance Database, the age-based defaults from Table 4.2.2.7.2.5(1) of ANSI 301, the EPA ENERGY STAR website or another reputable source. Record the location of the refrigerator -- whether it is in the Conditioned Space Volume of the Dwelling Unit, Unrated Heated Space or Unrated Conditioned Space. If there are refrigerators, freezers or wine coolers in multiple locations within the Dwelling Unit or building, then use the location that represents the majority of power consumption. Total consumption for refrigerators is additive. It shall include all the power consumed by all the refrigerators and/or freezers for use by the occupants of the Dwelling Unit.

Building Element: Dishwasher(s)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Total annual consumption of dishwasher	Determine and record the Energy Factor or total annual consumption of dishwasher	Record whether the dishwasher is or is not installed at the time of the inspection. When the dishwasher is installed at the time of inspection, record the model number of the dishwasher and determine and record the total annual consumption or Energy Factor from either the dishwasher Energy Guide Label, the California Energy Commission Appliance Database, the EPA ENERGY STAR website, or another reputable source. In addition, determine and record and record the place setting capacity. Record the location of the dishwasher, whether it is in the Conditioned Space Volume of the Dwelling Unit, Unrated Heated Space or Unrated Conditioned Space. If there are dishwashers in multiple locations within the Dwelling Unit or building, then use the location that represents the majority of power consumption.

Building Element: Range/Oven		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Total annual consumption of range/oven	Determine and record the total annual consumption of range/oven	Record whether the range/oven is or is not installed at the time of the inspection. When the range/oven is installed at the time inspection: • Determine and record and record the fuel source for cooking. If different fuels are used, select the fuel for the range. • Determine and record and record if the range is an induction range – Use model number to search for manufacturer's data sheet or another reputable source • Determine and record and record whether the oven is a convection oven or not – Use model number to search for manufacturer's data sheet or another reputable source

Building Element: Clothes Washer		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Total annual consumption of clothes washer	Determine and record the total annual consumption of clothes washer	Record whether the clothes washer is or is not installed at the time of the inspection. When the clothes washer is installed at the time inspection: • Record clothes washer model number. • Record the location of the clothes washer -- whether it is in the Conditioned Space Volume of the Dwelling Unit, Unrated Heated Space or Unrated Conditioned Space. • Determine and record the capacity in cubic feet and Modified Energy Factor (MEF) or the Integrated Modified Energy factor (IMEF) of the clothes washer from: – the manufacturer's data sheet, – the California Energy Commission Appliance Database, – the EPA ENERGY STAR website or another reputable source. When the clothes washers are located outside of the Dwelling Unit, in addition to the information above, record the number of clothes washers. To model performance credit for common area clothes washers, a minimum of one clothes washer per fourteen Dwelling Units is required. If a water heater, separate from the one serving the Rated Home, provides hot water to the clothes washer, record the nameplate data of the service hot water heating system that provides hot water to the clothes washers. See Service Hot Water heating section for the information required.

Building Element: Clothes Dryer		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Total annual consumption of clothes dryer	Determine and record the total annual consumption of clothes dryer	Record whether the clothes dryer is or is not installed at the time of the inspection. When the clothes dryer is installed at the time inspection: • Record clothes dryer model number. • Determine and record the fuel type of the dryer. • Determine and record whether the clothes dryer is moisture sensing or not. • Record the location of the clothes dryer -- whether it is in the Conditioned Space Volume of the Dwelling Unit, Unrated Heated Space, or Unrated Conditioned Space. • Determine and record the Efficiency Factor or Combined Energy Factor of the clothes dryer from: – the manufacturer's data sheet, – the California Energy Commission Appliance Database, – the EPA ENERGY STAR website, or another reputable source. When the clothes dryers are located outside of the Dwelling Unit, in addition to the information above, record the number of clothes dryers.

Building Element: Ceiling Fans		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Total annual consumption of ceiling fan	Determine and record the total annual consumption of ceiling fan	Record whether ceiling fans are or are not installed at the time of the inspection. When ceiling fans are installed at the time of the inspection: • Record the number of ceiling fans in the Dwelling Unit. For ceiling fans to be modeled, there must be one fan per Bedroom plus one more elsewhere in the Dwelling Unit. • Record the model number for all ceiling fans. • Record the average efficiency for the fans installed (cfm/W) at medium speed.

Building Element: Dwelling Unit Mechanical Ventilation System(s)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Centralized system equipment type	Data collection for centralized Dwelling Unit Mechanical Ventilation systems that serve more than one Dwelling Unit	*Centralized exhaust fans* – Record the model number from the nameplate data of each fan being utilized to provide Dwelling Unit Mechanical Ventilation. Use the fan model number to determine and record the fan cfm and wattage or horsepower from the manufacturer's data sheet. *Centralized supply or balanced system fans* – Record the model number from the nameplate data of each fan being utilized to provide ventilation air, directly or indirectly, to the Dwelling Unit. Record the percent of outdoor air in the supply air and whether the supply air is heated or cooled. If conditioned, record capacity and efficiency ratings of heating and cooling systems. Use the fan model number to determine and record the fan cfm and wattage or horsepower from the manufacturer's data sheet. For balanced systems, also record the sensible recovery efficiency and total recovery efficiency.
Individual system equipment type	Data collection for individual Dwelling Unit Mechanical Ventilation systems that serve a single Dwelling Unit	*Individual exhaust fans* – Determine and record the fan wattage and model number from the nameplate data of the exhaust fan being utilized to provide Dwelling Unit Mechanical Ventilation. Use the fan model number to determine and record the fan wattage from the manufacturer's data sheet or HVI Directory. Where the fan is operated using a programmed schedule, document the daily run time for the fan, using the ventilation controller run time setting as observed on-site. If the fan is set to run continuously, then document the daily run time as 24 hours. In Attached Dwelling Units, determine and record whether there is supply air provided to the Dwelling Unit, directly or indirectly from adjacent corridor. See Corridor Ventilation section for guidance. *Individual supply fans* - Record the fan wattage and model number from the nameplate data of the supply fan being utilized to provide Dwelling Unit Mechanical Ventilation. Use the fan model number to determine and record the fan wattage from the manufacturer's data sheet or HVI Directory. Where the fan is operated using a programmed schedule, document the daily run time for the fan, using the ventilation controller run time setting as observed on-site.

Building Element: Dwelling Unit Mechanical Ventilation System(s)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		If the fan is set to run continuously then document the daily run time as 24 hours. Record whether the supply fan is separate or integrated with the space conditioning system. *Individual Balanced Ventilation Fans* – These are commonly known as energy recovery ventilators (ERV) or heat recovery ventilators (HRV). Record model number from the nameplate data of the ERV/HRV. Use the model number to determine and record the fan wattage, sensible recovery efficiency and total recovery efficiency from the manufacturer's data sheet or HVI Directory. Where the fan is operated using a programmed schedule, document the daily run time for the fan, using the ventilation controller run time setting as observed on-site. If the fan is set to run continuously, then document the daily run time as 24 hours. *Central Fan Integrated Supply (CFIS) Ventilation System* – A central fan integrated Supply Ventilation System is a specific type of supply-only ventilation that includes a duct running from the outside into the return plenum of the heating/cooling system, a mechanical damper, and controls that ensure the system provides ventilation air even when there is no demand for heating or cooling. For these systems, record the central fan model number from the nameplate data of the air handler fan and whether it is equipped with an ECM motor. Use the fan model number to determine and record the fan cfm and either horsepower or wattage from the manufacturer's data sheet. Where fan wattage is not provided, use (HP x 746)/0.90 to calculate fan wattage. Where the fan has multiple speeds, use values associated with the high-speed setting to select or calculate the fan wattage. *Unit ventilator* – Similar to the CFIS system, a fan coil unit can be designed to provide both space conditioning and mechanical ventilation to the space that it is serving. Classify as a ventilation system only if the unit operates

Building Element: Dwelling Unit Mechanical Ventilation System(s)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
		continuously with the outside air damper open or if the damper is controlled to allow the supply of ventilation air when there is no call for heating or cooling.
Dwelling Unit Mechanical Ventilation rate	Measure exhaust and supply airflow	Ventilation airflows in the Dwelling Unit shall be measured following the procedures in ANSI/RESNET/ICC 380.

Building Element: Corridor Ventilation		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Supply Ventilation	Determine and record whether a corridor ventilation system is used to directly or indirectly supply the adjacent Dwelling Units with ventilation air	Document whether or not weatherstripping and a door sweep are installed on the Dwelling Unit entry door. Document whether or not there is a Supply Ventilation System serving the adjacent common corridor. If there is a Supply Ventilation System serving the adjacent common corridor, then record the model number from the nameplate of that system. Use the model number to determine and record if the ventilation air is being heated or cooled, the percent of outdoor air supplied, the fan power and heating/cooling efficiencies.

Building Element: On-Site Power Production		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Annual electricity generation for On-Site Power Production (OPP) systems	Data collection for On-Site Power Production systems	*On-Site Power Production systems* – Collect documentation that shows the annual kWh/y generated. For combined heat and power systems, the documentation shall include the annual gas use in addition to kWh/y generated. *Photovoltaic Systems* – In situations where the Approved Software Rating Tool calculates electricity generation from photovoltaic systems, determine and record the following: • the orientation of the photovoltaic array to the nearest cardinal/ordinal point, in the direction the array faces; • the tilt of the array. Use an angle finder instrument or geometric calculation; • the area of the array and the peak power using the information on the SRCC label or manufacturer's data sheet; and • the efficiency of the inverter using the manufacturer's data sheet.

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

	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)
Window Film or Tint	15	10				10		10-15
Window Solar Screens	15	10						10-15

1. Residential Energy Service Network (RESNET). "Mortgage Industry National Home Energy Rating Systems Standards," March 2, 2012
2. Database for Energy Efficient Resources (DEER). "DEER 2008 for 09-11 Planning/Reporting." 2008. http://www.deeresources.com May, 10, 2012
3. California Measurement Advisory Council (CALMAC): CALMAC Protocols. "Appendix F: Effective Useful Life Values for Major Energy Efficiency Measures." 1994-2007. http://www.calmac.org/events/APX F.pdf May 10, 2012
4. American Council for an Energy-Efficient Economy (ACEE): "Consumer Resources by Measure Type" January 2011. www.acee.org May 10, 2012
5. Navigant Consulting. "EIA – Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case Second Edition (Revised)." Sept 2007.
6. National Association of Home Builders (NAHB): "National Association of Home Builders/Bank of America Home Equity Study of Life Expectancy of Home Components." February 2007. http://www.nahb.org/fileUpload_details.aspx?contentID=99359 May 10, 2012.
7. Residential Energy Service Network (RESNET). Standard Development Committee estimate for Standard 301. June 2012.

ANSI/RESNET/ICC 301-2022 Addendum A-2022,

Renewable Energy Certificates and Infiltration Volume

Revise current and add new definitions as follows:

Infiltration Volume[138]

– The sum of the ~~Conditioned Space Volume~~following spaces of the subject Dwelling Unit~~,~~:

- The Conditioned Space Volume, excluding any Attics, basements, crawlspaces, and adjacent mechanical closets.
- ~~plus t~~The Conditioned Space Volume and Unconditioned Space Volume of the following adjacent spaces if included[139]
- during the airtightness measurement of the enclosure: Attics, crawlspaces and the full depth of their floor assemblies above, basements and the full depth of their floor assemblies above, and adjacent mechanical closets and the full width of their wall assemblies between them and the subject Dwelling Unit.

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-percent conversion efficiency in accordance with Equation 4.1-3 of this Standard.

Renewable Energy Certificate (REC): a market-based instrument that represents and conveys the environmental, social, and other non-power attributes of one megawatt-hour of renewable electricity generation.

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.

Add CSV to list of acronyms:

3.3 Acronyms

CFA – Conditioned Floor Area

---

[20](Informative Note) Informative Annex A of Standard ANSI/RESNET/ICC 380 contains a table that summarizes parts of a Dwelling Unit that are included in Infiltration Volume.

[21] (Informative Note) Sections **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, and **Error! Reference source not found.** of Standard ANSI/RESNET/ICC 380 define whether these adjacent spaces are to be included in Infiltration Volume.

CSV – Conditioned Space Volume
CFIS – Central Fan Integrated Supply

Modify the Thermal Distribution Systems row of Table 4.2.2 (1) as follows:

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

Thermal distribution systems	Thermal Distribution System Efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies.	Forced air distribution systems duct leakage to outside tests[w,x, y, z , yy] shall be conducted and documented by an Approved Tester in accordance with requirements of Standard ANSI/RESNET/ICC 380 with the air handler installed, and the energy impacts calculated with the ducts located and insulated as in the Rated Home. Forced air distribution systems duct area shall be the same as the Rated Home[aa]. For ductless distribution systems or distribution systems in CSV with the supply-side having a total length that does not exceed 10 ft., inclusive of both ductwork and building cavities used for distribution: DSE=1.00 For hydronic distribution systems: DSE=1.00

Modify table note h. for Table 4.2.2(1) as follows:

h. Either hourly calculations using the following equation[121] 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.

~~$Q_i = Q_{fan,i} + \Phi Q_{inf,i}$~~

$Q_i = Q_{fan,max,i} + \Phi (Qinf,i)^2 / (Qinf,I + Qimb,i)$

where:

~~Φ = 1 for Balanced Ventilation Systems and otherwise~~

~~$\Phi = Q_{inf,i} / (Q_{inf,i} + Q_{fan,i})$~~

Q_i = *combined* air exchange rate for the time step 'i', cfm

$Qfan,max,i$ = *MAX(Qfan_sup, Qfan_exh)* for the time step 'i', cfm

$Qfan,sup,i$ = supply fan air flow rate for time step 'i', cfm

$Qfan,exh,i$ = exhaust fan air flow rate for time step 'i', cfm

$Q_{inf,i}$ = Infiltration airflow rate for the time step 'i', cfm calculated using Shelter Class 4

$Qimb,i$ =*ABS(Qfan_sup - Qfan_exh)* for time step 'i', cfm

~~$Q_{fan,i}$ = *mechanical* Ventilation airflow rate for the time step 'i', cfm~~

Modify row 26 of Table 4.5.2 as follows:

Table 4.5.2(1) Minimum Rated Features	
Building Element	**Minimum Rated Feature**
26. On-site Power Production	System type, total annual kWh generation, Renewable Energy Certificates (RECs) status [retired, retained ownership, sold/transferred, none associated with system, unknown], and total site fuel used in the On-Site Power Production as derived from manufacturer's performance ratings.

[121] ~~(Informative Note) Equation taken from ASHRAE Standard 62.2-2016, Normative Appendix C, equations (C7) and (C8).~~

Modify the Appendix B table as follows:

Building Element: On-Site Power Production		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Annual electricity generation for On- Site Power Production (OPP) systems	Data collection for On-Site Power Production systems	*On-Site Power Production systems* – Collect documentation that shows the annual kWh/y generated. For combined heat and power systems, the documentation shall include the annual gas use in addition to kWh/y generated. *Renewable Energy Systems* – Collect documentation or other information to determine whether Renewable Energy Certificates (RECs) are associated with the system, and document the RECs status as retired, retained ownership, sold/transferred, none associated with system, unknown. *Photovoltaic Systems* – In situations where the Approved Software Rating Tool calculates electricity generation from photovoltaic systems, determine and record the following: • the orientation of the photovoltaic array to the nearest cardinal/ordinal point, in the direction the array faces; • the tilt of the array. Use an angle finder instrument or geometric calculation; • the area of the array and the peak power using the information on the SRCC label or manufacturer's data sheet; and • the efficiency of the inverter using the manufacturer's data sheet.

ANSI/RESNET/ICC 301-2022 Addendum B-2022,

CO2e Index

Revise table note x. for Table 4.2.2(1) Specifications for the Energy Rating Reference and Rated Homes as follows:

x. Any untested forced air distribution system is permitted to be modeled with a DSE of 0.70. When both of the following conditions are met and documented, duct leakage testing is also not required.

3. At a pre-drywall stage of construction, 100 percent of the ductwork and airhandler shall be visible and visually verified to be contained inside the Conditioned Space Volume.
4. At a final stage of construction, ductwork that is visible and the air handler shall be verified again to be contained in the Conditioned Space Volume.

To calculate the energy impacts on the Rated Home, a DSE of 0.80, shall be applied to both the heating and cooling system efficiencies.

<u>If at the pre-drywall stage of construction, the ductwork is visually verified to be 100 percent fully ducted with no building cavities used as supply or return ducts, a DSE of 0.88 shall be applied to both the heating and cooling system efficiencies.</u> As an alternative to the DSE = 0.88, a value of 4 cfm per 100 square feet of Conditioned Floor Area may be modeled for duct leakage to outside if the above conditions are met and no ductwork is contained within envelope assemblies adjacent to the exterior or Unconditioned Space Volumes. ~~If at a pre-drywall stage of construction, the ductwork is visually verified to be 100 percent fully ducted with no building cavities used as supply or return ducts, a DSE of 0.88 shall be applied to both the heating and cooling system efficiencies.~~

Revise table note (a) for Table 4.3.1(1), Configuration of Index Adjustment Design, as follows:

Table 4.3.1(1) Configuration of Index Adjustment Design

Table 4.3.1(1) Notes:

(b) The procedure for determining the combined air exchange rate resulting from infiltration combined with Dwelling Unit Mechanical Ventilation Systems ~~is~~<u>shall be</u> consistent with that shown in Table 4.2.2(1) table notes (g) and (h).

Revise section 7.1.2.2. as follows:

7.1.2.2. Emission. The emissions for the Rated Home shall be calculated in accordance with Sections 7.1.2.2.1 and 7.1.2.2.2.

7.1.2.2.1. Emissions. Emissions for all homes shall be calculated in accordance with Sections 7.1.2.2.1.1. and 7.1.2.2.1.2.

7.1.2.2.1.1. For electricity use, data for the sub-region annual total output emission rates published by Environmental Protection Agency's ~~2019 eGrid~~2020 eGRID database[212] for electricity generation shall be used to calculate emissions.[213] ~~except CO_2~~CO_2e emissions, which shall be calculated using the ~~Cambium database[214,94] for the most recent year's Mid-case, average hourly CO_2 generation rate (*co2_rate_avg_load_enduse*: kgCO_2 per MWh_{enduse}) for the local ZIP Code~~ provisions of Section ~~6.2~~8.2 to calculate the annual hourly CO_2e emissions for the Rated Home.

7.1.2.2.1.2. For fossil fuel use, emissions shall be calculated using the emission factors given in Table 7.1.2(1).

Table ~~5~~7.1.2(1) Emission Factors for Household Combustion Fuels[9593]

Fuel Type	Units	MBtu per Unit	~~CO_2~~CO_2e lb/MBtu	NOx lb/MBtu	SO_2 lb/MBtu
Natural Gas	Therm	0.1000	~~117.6~~147.3	0.0922	0.0006
Fuel Oil #2	Gallon	0.1385	~~161.0~~195.9	0.1300	0.0015
Liquid Petroleum Gas (LPG)	Gallon	0.0915	~~136.46~~177.8	0.1421	0.0002

7.1.2.2.2. Emission Savings. Estimated emission savings for the Rated Home shall be calculated in accordance with Sections 7.1.2.2.2.1. through 7.1.2.2.2.3.

7.1.2.2.2.1. The CO_2e Index Reference Home shall be identical to the Energy Rating Reference Home except that it shall use electricity for all energy end uses. The ~~Energy Rating Reference Home~~ emissions for the CO_2e Index Reference Home shall be determined ~~by fuel type~~ by applying the emission factors ~~emissions~~ determined

[212] (Informative Reference) http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
[213] (Informative Note) RESNET will compile and publish annual total output emission rate data for NOx, SO_2 and ~~CO_2~~CO_{2e} in accordance with the provisions of this section that can be used by Approved Software Rating Tools for the calculation of emissions.
[214] https://cambium.nrel.gov/
[94] Gagnon, Pieter, Will Frazier, Elaine Hale, and Wesley Cole, 2020. "Cambium Documentation: Version 2020." Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-78239.
[9521]4 (Informative Note) Developed from the U.S. EPA AP 42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1, Chapter 1: External Combustion Sources. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-1-external-0

in accordance with Section 7.1.2.2.1 to ~~the~~ its Purchased Energy ~~individual fuel types of the Energy Rating Reference Home~~.

7.1.2.2.2.2. The Rated Home emissions shall be determined by fuel type by applying the ~~same~~ emission factors determined in accordance with ~~data used for the Energy Rating Reference Home in~~ Section ~~0~~7.1.2.2.1 ~~above~~.

7.1.2.2.2.3. For Confirmed, Sampled and Projected Ratings, estimated emission savings shall be calculated in accordance with Sections 7.1.2.2.2.3.1. and 7.1.2.2.2.3.2.

7.1.2.2.2.3.1. Estimated emission savings with respect to the ~~Energy Rating Reference Home~~ CO_2e Index Reference Home shall be the difference between the emissions of the ~~Energy Rating Reference~~ CO_2e Index Reference Home and the emissions of the Rated Home.

7.1.2.2.2.3.2. Estimated emission savings with respect to the Typical Existing Home shall be determined in accordance with Sections 7.1.2.2.2.3.2.1. and 7.1.2.2.2.3.2.2.

7.1.2.2.2.3.2.1. ~~For each fuel type, m~~Multiply the ~~Energy Rating Reference Home~~ CO_2e Index Reference Home emissions by 1.3 to determine the Typical Existing Home emissions by fuel type.

7.1.2.2.2.3.2.2. Estimated emission savings with respect to the Typical Existing Home shall be the difference between the emissions of the Typical Existing Home and the emissions of the Rated Home.

Revise section 7.3. as follows:

7.3. Labeling. Energy Rating labels shall, at a minimum, contain the information specified by Sections 7.3.1 through 7.3.8.

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

7.3.2. Energy Rating Index of the home.

7.3.3 ~~CO$_2$~~CO_2e Index for the home, calculated in accordance with Section 6.

7.3.4 Projected ~~CO$_2$~~CO_2e emissions for the home, calculated in accordance with Sections ~~5~~7.1.2.2.1.1 and ~~5~~7.1.2.2.1.~~1~~2.

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

7.3.6. Projected annual energy cost of the home[220],

calculated in accordance with energy price rate provisions of Section 7.1.2.1.1.

7.3.7. Name and address of the Approved Rating Provider.

7.3.8. Date of the Energy Rating.

Revise section 8. as follows:

8. ~~CO_2~~ CO_2e **Rating Index.** The ~~CO_2~~ CO_2e Index shall be calculated for the Rated Home in accordance with equation ~~6-1~~8.1 using the provisions of Sections ~~6~~8.1 through ~~6.5~~8.4

~~CO_2~~ CO_2e Index = ACO2 / (ARCO2 * IAF_{RH}) * 100 (Equation **~~6~~8-1)**

where:

ACO2 = Annual hourly ~~CO_2~~ CO_2e emissions from the Rated Home

ARCO2 = Annual hourly ~~CO_2~~ CO_2e emissions from the ~~CO_2~~ CO_2e Index Reference Home

IAF_{RH} = Index Adjustment Factor in accordance with Equation 4.3-2

8.6 The ~~CO_2~~ CO_2e emission factors for household combustion fuel use shall be those given in Table ~~5.1.2(1)~~7.1.2(1).

8.7 The ~~CO_2~~ CO_2e emission factors for electricity use shall be the levelized ~~CO_2~~ CO_2e combined combustion and pre-combustion, end-use emission rates having 100-year IPCC 6th Assessment Report Global Warming Potential as calculated using the 2021 Cambium database[100,101] for the Low Renewable Energy Cost Scenario for the Long-Run Marginal month-hour CO_2e emission rates (lrmer_co2e) for the applicable Cambium Grid and Emission Assessment (GEA) region in accordance with the local ZIP Code using equation 8-2 with a starting year of 2025.[102,103,104] ~~emission factors calculated using the Cambium database[100,101] for the Low Renewable Energy Cost Scenario for the Long-Run~~

---

[220] (Informative Note) The projected energy cost shown on the label might not reflect the projected energy costs to be paid by the occupant as metering configurations can result in certain energy costs and end-uses being paid by the building owner.

[100] (Normative Note) https://cambium.nrel.gov/

[101] ~~Gagnon, Pieter, Will Frazier, Elaine Hale, and Wesley Cole, 2020. "Cambium Documentation: Version 2020." Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-78239.~~

[101] (Normative Note) Gagnon, Pieter; Frazier, Will; Hale, Elaine, Cole, Wesley (2022): Long-run Marginal Emission Rates for Electricity - Workbooks for 2021 Cambium Data. National Renewable Energy Laboratory, Golden, CO. https://data.nrel.gov/submissions/183

[102] (Informative note) National Renewable Energy Laboratory (NREL) provides a spreadsheet tool for the calculation of levelized CO_{2e} emission rates that can be accessed at https://data.nrel.gov/submissions/183.

[103] (Informative Note) RESNET provides a spreadsheet of the hourly emission factors and ZIP code mappings that meet these criteria that can be accessed at https://www.resnet.us/wp-content/uploads/RESNET_2021_CO_{2e}_GEAdata.xlsx.

[104] (Informative Note) These Cambium CO_2e emission data are provided in units of kg/MWh.

~~Marginal enduse CO_2 generation rate (*co2_lmer_enduse*: kgCO_2 per MWh$_{enduse}$) for the local ZIP Code using equation 6-2 with a starting year of 2025.~~[223]

$$LRMER_{levelized} = \frac{\sum_{t=0}^{n-1} \frac{LRMER_t}{(1+d)^t}}{\sum_{t=0}^{n-1} \frac{1}{(1+d)^t}}$$ **(Equation ~~6~~8-2)**

where:

$LRMER_t$ = long-run marginal emission rate for year t
d = real social discount rate = 0.03
n = evaluation period in years = 25

8.8 The ~~CO_2~~ CO_2e emission factors shall be applied to the hourly Purchased Energy by fuel type for both the Rated Home and the ~~CO_2~~ CO_2e Index Reference Home.

8.9 The ~~CO_2~~ CO_2e Index Reference Home shall be identical to the Energy Rating Reference Home except that it shall use electricity for all energy end uses.

~~8.10 Where reported, the CO_2 savings for the Rated Home shall be the CO_2 emissions for the CO_2 Index Reference Home minus the CO_2 emissions for the Rated Home.~~

9. Normative References.

ANSI/RESNET/ICC ~~380-2019~~380-2022, "Standard for Testing Airtightness of Building, Dwelling Unit, and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems; and Airflow of Mechanical Ventilation Systems" and ANSI Approved Addenda. Residential Energy Services Network, Oceanside, CA.

~~[102] (Informative note) National Renewable Energy Laboratory (NREL) provides a spreadsheet tool for the calculation of levelized CO_2 emission rates. The NREL spreadsheet tool uses the input parameters specified by this section as inputs to the spreadsheet tool.~~