

VERMONT HOME ENERGY RATING TECHNICAL GUIDELINES

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A. GENERAL PROVISIONS

1. **Purpose.** The provisions of this document are intended to establish Vermont residential energy efficiency rating Guidelines, consistent with the provisions of the NASEO/RESNET National Home Energy Rating Technical Guidelines, which any provider of home energy ratings in Vermont must follow to produce uniform energy efficiency ratings for residential buildings.
 - a. **Relationship to other Guidelines.** These Guidelines are a companion document to the “Vermont Home Energy Rating System Provider Accreditation Standards” as established by the Vermont Department of Public Service.
2. **Scope.** These Guidelines apply to existing or proposed, site-constructed or manufactured, one and two family residential buildings, or other residential buildings excepting hotels and motels.
3. **Definitions and acronyms.**

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

Accrediting Body – Vermont Department of Public Service

Accreditation Procedures – The set of standards and procedures entitled “Accreditation Procedures for Home Energy Rating System Providers” as established by the Vermont Department of Public Service.

Adiabatic – A condition wherein heat neither enters nor leaves a system.

Annual Fuel Utilization Efficiency or *AFUE* – The ratio of annual output energy to annual input energy that includes any non-heating season pilot input loss.

Climate zone – A geographical area defined as having similar long-term climate conditions.

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

Conditioned space boundary – The continuous planes of the building envelope that comprise the primary thermal and air flow barrier between the directly or indirectly conditioned space and either the outdoors or an adjacent unconditioned space.

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

Data analyst – A person trained to enter the information compiled by a data collector into the rating tool and to produce the energy efficiency rating of a home.

Data collector – A person trained to evaluate the minimum rated features of a home on site and collect all the information required to create a rating.

Detached one- and two-family dwelling – A building with one or two independent dwelling

units with an individual or central HVAC system.

Directly Conditioned space – An enclosed space having heating equipment with a capacity exceeding 10 BTU/hr-ft², or cooling equipment with a capacity exceeding to 10 BTU/hr-ft². An exception is if the heating and cooling equipment is designed and thermostatically controlled to maintain a process environment temperature less than 65° Fahrenheit or greater than 85° Fahrenheit for the whole space the equipment serves.

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

Energy analysis tool – A calculation procedure for determining a home’s energy efficiency rating and estimating annual purchased energy consumption and cost.

EER – Energy Efficiency Ratio, which is the ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

Energy efficiency rating or rating – An unbiased indication of a home’s relative energy efficiency based on consistent inspection procedures, operating assumptions, climate data and calculation methods as generated through application of these Technical Guidelines by a Vermont accredited home energy rating organization.

Energy factor – A measure of water heater energy efficiency as determined under Department of Energy Regulations, 10 CFR 430.23(e)(2)(ii).

Energy saving measure or feature – Any material, component, device, system, construction method, process or combination thereof that will result in a reduction of energy use.

EPAct – The U.S. Energy Policy Act of 1992.

Estimated annual energy cost savings – Positive dollar difference between estimated annual energy costs for a home with energy saving measures and estimated annual energy costs of the same home in its current condition.

Exposed wall – Walls subjected to heat loss or gain.

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

Heating Degree Day (HDD) – A unit, based upon temperature difference and time, used in estimating fuel consumption. For any one day when the mean temperature is less than 65 degrees F, there exists as many heating degree-days as there are Fahrenheit degrees difference in temperature between the mean temperature and 65 degrees F. (MEC, 1995)

HERS or Home Energy Rating System. The materials and procedures used by a HERS provider including but not limited to: marketing materials, training materials, publications, rating tool, quality control, data bases collection and maintenance, agreements, data collection sheets, home owner reports, and other related materials and services.

HERS Accreditation Procedures – The set of standards and procedures entitled “Accreditation Procedures for Home Energy Rating System Providers” as established by the Vermont Department of Public Service.

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

HERS provider – A person or organization, accredited by the Vermont Department of Public Service to develop, manage, and perform home energy ratings.

Home – A one- or two-family dwelling or multi-family dwelling of three stories or less.

Home energy rater or rater – The person trained to perform the functions of both a data collector and a data analyst, and to inspect a home to evaluate the minimum rated features and prepare an energy efficiency rating (see also Data collector and Data analyst) and acting under the direct supervision of a Vermont accredited home energy rating organization.

Home Energy Rating System or HERS -

HSPF or Heating Seasonal Performance Factor - The total heating output of a heat pump during its normal annual usage period for heating, in Btu, divided by the total electric energy input during the same period, in watt-hours.

HVAC – Heating, Ventilating and Air Conditioning.

Indirectly Conditioned space – Enclosed space that is not directly conditioned:

(1) With area weighted heat transfer coefficient (U-value) to directly conditioned space exceeding that to the outdoors or to unconditioned spaces; or

(2) through which air to or from directly conditioned spaces is transferred at a rate exceeding three air changes per hour.

Internal gains – The heat gains within a home attributable to lights, people, and miscellaneous equipment including domestic hot water equipment losses.

MEC '93 – the Model Energy Code as promulgated by the Council of American Building Officials (CABO) in 1993 as amended in 1994.

NASEO – National Association of State Energy Officers.

NREL – National Renewable Energy Laboratory.

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

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

Rated Home – The specific home being evaluated using the rating procedures and Guidelines contained in this document.

Rating tool – A procedure for calculating a home's energy efficiency rating, annual energy consumption, and annual energy costs.

Reference Home – A hypothetical home configured in accordance with the specifications set forth in Section B.4 of these Guidelines.

RESNET – Residential Energy Services Network.

R-value – thermal resistance value measured in $\text{h-ft}^2\text{-F/Btu}$.

SE - The ratio of annual output energy to annual input energy that includes any non-heating season pilot input loss.

SEER – Seasonal Energy Efficiency Ratio, which is the total cooling output of an air conditioner during its normal annual usage period for cooling, in Btu/h, divided by the total electric energy input during the same period, in watt-hours.

Thermal boundary wall – Any wall that separates directly or indirectly conditioned space from unconditioned space or ambient conditions.

Thermal boundary wall, above-grade is any thermal boundary wall not in contact with soil.

Thermal storage mass – Materials or equipment incorporated into a home that will store heat, produced by renewable or non renewable energy, for release at a later time.

Typical Meteorological Year or TMY Data – Hourly climate data published by the National Climatic Center, Asheville, NC, based on historical climate data in 216 locations.

U-value – Thermal transmittance value measured in $\text{Btu/h-ft}^2\text{-F}$.

B. TECHNICAL REQUIREMENTS FOR CONDUCTING RATINGS

1. Rating procedure

- a. To determine the energy efficiency rating of a home, all HERS providers shall—
 - (1) If rating an existing home, visit the home to collect the data needed to calculate the rating;
 - (2) If rating a new, to-be-built home, follow the procedures set forth in Section B.8 of these Guidelines to collect the data needed to calculate the rating;
 - (3) Use the collected data to estimate the annual purchased energy consumption for heating, cooling and water heating for both the Rated Home and the Reference Home as defined in Section B.4 of these Guidelines.
 - (4) If the energy efficiency rating is conducted to evaluate proposed energy conserving improvements to the home, calculate additional estimates of annual purchased energy consumption with the home reconfigured to include those improvements sufficient to consider interactions among improvement options.
- b. Estimates completed by all HERS providers under paragraphs a.(3) and a.(4) of this section must be—
 - (1) Based on the minimum rated features set forth in Section B.5 of these Guidelines.
 - (2) Conducted using the standard operating assumptions established in Section B.6 of these Guidelines.
 - (3) Conducted using an energy analysis (rating) tool that has been certified for accuracy under Section C.1 of these Guidelines.
- c. Ratings must compare the estimates provided under paragraph B.1.a. of this section to determine the energy efficiency rating of the home and, if applicable, the energy efficiency rating of the home with proposed conservation measures installed.
- d. To encourage the use of energy efficient lights and appliances, HERS providers may provide additional information on estimated lights and appliance energy consumption in the Rated Home consistent with section B.7.

2. Rating point score and star rating.

- a. Point score. The Reference Home shall have a point score of 80 points on a 0 to 100 point scale. Each 5% increase or decrease in the relative energy efficiency potential of the Rated Home with respect to the Reference Home shall constitute a 1 point increase or decrease, respectively (from 80), in the Rated Home's score. The method used to calculate the score shall be consistent for each HERS provider operating in Vermont. Equations 1 and 2 shall be used in a 2-step process to calculate the point score for the Rated Home, as follows:

Step (1) Calculate the individual normalized Modified End Use Loads (nMEUL) for heating, cooling, and hot water using equation 1:

$$\mathbf{nMEUL = REUL * (nEC_x / EC_r)} \quad \mathbf{(Eq. 1)}$$

where:

nMEUL = normalized Modified End Use Loads (for heating, cooling or hot water).

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

nEC_x = normalized Energy Consumption for Rated Home's end uses (for heating, cooling or hot water) as calculated below.

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

$$\mathbf{nEC_x = (a * EEC_x - b) * (EC_x * EC_r * DSE_r) / (EEC_x * REUL)}$$

where:

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

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

$$DSE_r = REUL / EC_r * EEC_r$$

where:

For simplified system performance methods, DSE_r equals 0.80 for heating and cooling systems and 1.00 for hot water systems. [see Section B.4.a.(16)]. However, for detailed modeling of heating and cooling systems, DSE_r may be less than 0.80 as a result of part load performance degradation, coil air flow degradation, improper system charge and auxiliary resistance heating for heat pumps. Except as otherwise provided by these Guidelines, 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_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.

and where:

the coefficients 'a' and 'b' are as defined by Table 1 below:

Table 1. Coefficients 'a' and 'b'

Fuel type and End Use	a	b
Electric space heating	1.9924	0
Fuel-fired space heating	1.2544	0.6082
Electric air conditioning	2.9301	0
Electric water heating	0.8800	0
Fuel-fired water heating	0.9404	0.7415

Step (2) Determine the point score using equation 2:

$$\text{Point score} = 100 - ((TnML / (TRL * (1 - VRF))) * 20) \quad (\text{Eq. 2})$$

where:

$TnML = nMEUL_{HEAT} + nMEUL_{COOL} + nMEUL_{HW}$ (Total of all normalized Modified End Use Loads as calculated using equation 1).

$TRL = REUL_{HEAT} + REUL_{COOL} + REUL_{HW}$ (Total of all Reference Home End Use Loads).

$VRF =$ Vermont Reference Factor of 12.1% (0.121).

- b. Star rating. The Rated Home will be given a star rating between one and five-plus stars, determined by the numerical score and the corresponding number of stars depicted in Table 2:

TABLE 2. Score, Star and Efficiency Scales for Rated Homes

Score Range	Stars	Relative Efficiency Change (with respect to Reference Home)
=>0 and <20	☆	=>-400% and < -300%
=>20 and <40	☆+	=>-300% and < -200%
=>40 and <50	☆☆	=>-200% and <-150%
=>50 and <60	☆☆+	=>-150% and < -100%
=>60 and <70	☆☆☆	=>-100% and <-50%
=>70 and <80	☆☆☆+	=>-50% and <0%
=>80 and <83	☆☆☆☆	=>0% and <15%
=>83 and <86	☆☆☆☆+	=>15% and <30%
=>86 and <90	☆☆☆☆☆	=>30% and <=50%
=>90 and <=100	☆☆☆☆☆+	=>50%

3. Rating report.

- a. For each rating conducted under this part, a report shall be prepared containing, at a minimum, the following information:
 - (1) The numerical rating score determined in Section B.2.a of these Guidelines;
 - (2) The star rating determined in Section B.2.b of these Guidelines;
 - (3) The estimated annual purchased energy consumption for space heating, space cooling, domestic hot water, and all other energy use, and the total of these four estimates;
 - (4) The estimated annual energy cost for space heating, space cooling, domestic hot water, and all other energy use, and the total of these four estimates;
 - (5) The unique physical location (full street address or recorded real property identifier) of the Rated home;
 - (6) The name of the individual performing the rating;
 - (7) The date the rating was performed; and
 - (8) The rating tool (including version number) used to calculate the rating;
- b. If ratings are conducted to evaluate energy saving improvements to the home, in addition to the information set forth under paragraph B.3.a of this section, each rating report must include—
 - (1) The estimated annual energy cost savings for the home reconfigured to include those improvements;
 - (2) The discount rate applied to, and present worth value of the energy cost savings; and
 - (3) The financing interest rate and the life of the measures used by the HERS provider to determine the present worth value.
- c. The rating report must also provide either:

- (1) The estimated lights and appliance energy consumption of the Rated Home: or
 - (2) Information that additional energy savings related to lights and appliance use may be attainable and that the information available on Energy Guide labels and from other recognized sources may be used to consider the energy efficiency of appliances.
- d. If a Projected Rating conducted under Section B.8.a of these Guidelines, the Rating shall be identified as a Projected Rating.
- e. For each rating conducted under these Guidelines, the following items are to be prominently displayed on all reports and labels:
- (1) Date of the rating;
 - (2) Annual estimated energy costs for heating, cooling, water heating and all other use;
 - (3) Rating point score; and
 - (4) Star rating;
 - (5) As an alternative to reporting the rating point score and star rating, any home achieving a rating score of 86 or greater and meeting the Vermont ENERGY STAR[®] Home standards as approved by the U.S. Environmental Protection Agency may, at the request of the person for whom the rating is being conducted, be labeled an ENERGY STAR[®] Home.

4. **Reference Home configuration.**

- a. All HERS providers shall establish a Reference Home used in an annual purchased energy consumption comparison with the Rated Home. The Reference Home is a hypothetical home having the following characteristics –
- (1) The same annual heating degree days as the Rated Home, from the nearest weather station data.
 - (2) The same shape and size as the Rated Home;
 - (3) The same area of surfaces bounding Conditioned Space as the Rated Home,
 - (4) All enclosure elements that meet, but not exceed, the requirements, expressed as U and U₀ values, of Paragraph 502.2 of MEC '93 with the components that meet the U₀ requirement for walls determined by:
 - (a) For detached one and two family homes, the U-values for wall assemblies from Table 3a; or
 - (b) For attached homes, the U-values for wall assemblies from Table 3b; and for all homes-

Table 3a. Opaque wall U-values (U_W) for detached homes

Heating degree days base 65 (HDD65) From nearest location listed in Chapter 9 of ASHRAE Standard 90.2	U_W air to air Includes framing
> 13000	0.038
9000-12999	0.046
6500-8999	0.052
4500-6499	0.058
3500-4499	0.064
2600-3499	0.076
<2600	0.085

Table 3b. Opaque wall U-values (U_W) for attached homes

Heating degree days base 65 (HDD65) From nearest location listed in Chapter 9 of ASHRAE Standard 90.2	U_W air to air Includes framing
>9000	0.064
7100-8999	0.076
3000-7099	0.085
2800-2999	0.100
2600-2799	0.120
<2600	0.140

(c) The U-values for fenestration calculated using Equation 3 or $U=1.3$, whichever is less;

Equation 3:
$$U_F = [(U_O \times A_O) - (U_W \times A_W) - 8] / A_F$$

Where:

U_F = Required average U-value of the fenestration systems.

U_O = Average U-value requirement for walls from paragraph 502.2 of MEC '93.

A_O = Gross exposed wall area, not including basement walls, of the Rated Home.

U_W = Value from Table 2a or 2b based on HDD65 criteria of Rated Home location.

A_W = Net opaque wall area, calculated as: $A_O - A_F - 40$.

A_F = Area of fenestration calculated using the gross area calculated under Section B.4.a.8 of these Guidelines

Note: For walls of attached homes, the U-value calculation in paragraph (3) above is completed using the fenestration area calculated as A_F in Section B.4.a.8 of these Guidelines and the actual area of walls that experience heat loss or gain. Areas of

common walls that separate homes are not included in A_0 , Equation 3.

- (5) The same foundation type as the Rated Home, where:
 - (a) For Rated Homes on ventilated crawl spaces, assume for the Reference Home, insulation of the floor above the crawl space meeting the requirements of MEC '93;
 - (b) For Rated Homes on non-ventilated crawl spaces, assume for the Reference Home, insulation of the crawl space walls meeting the requirements of MEC '93;
 - (c) For Rated Homes on basements that are directly or indirectly conditioned spaces, assume for the Reference Home, insulation of the basement walls meeting the requirements of MEC '93;
 - (d) For Rated Homes with slab on grade construction, assume insulation of the slab edge meeting the requirements of MEC '93;
- (6) Solar absorptivity of opaque areas of exterior walls of 0.50 and of opaque areas of roofs of 0.75;
- (7) An area of exterior doors of 40 square feet, facing north, and with the door U-value at 0.20.
- (8) Vertical fenestration area (A_F) is determined-
 - (a) for one and two family detached homes, by equation 4;
 - (b) for attached homes, by equation 5.

Equation 4: $A_F = 0.18 \times A_{FL} \times F_A$

Equation 5: $A_F = 0.18 \times A_{FL} \times F_A \times F$

Where: A_F = Total fenestration area.

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

F_A = (Above grade thermal boundary wall area)/(total thermal boundary wall area).

F = (Above grade thermal boundary wall area)/(above grade thermal boundary wall area + common wall area) $\geq .56$

And where:

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

Above grade thermal boundary wall is any thermal boundary wall not in contact with soil.

- (9) Vertical fenestration distributed-
 - (a) For detached homes, equally in each of the four cardinal directions, north, south, east and west; and
 - (b) For attached homes, equally in each of the four cardinal

directions, north, south, east and west, which if necessary may require fenestration facing the same direction as common walls;

- (10) A frame factor equal to 27% of the gross fenestration area calculated under Section B.4.a.8. of these Guidelines;
- (11) The glazed area of the fenestration with a shading coefficient (SC) of 0.70 assumed during the cooling season, which represents the combined SC of the glazing and the use of nonwhite draperies; and with a SC of 0.88, representing the SC of the glazing only, assumed at all other times;
- (12) No external shading assumed at any time;

Note: For the calculation of solar gains from all fenestration areas determined under Section B.4.a.8 of these Guidelines, the values in Table 4 are used to represent the combined effect of the framing factor in Section B.4.a.10. of these Guidelines and the glazed area shading coefficients in Section B.4.a.11. of these Guidelines.

Table 4. Shading and Solar Heat Gain Coefficients

	SC ¹	SHGC ²
Heating	0.675	0.581
Cooling	0.541	0.466

¹ For calculation tools using shading coefficients

² For calculation tools using solar heat gain coefficients as defined by NFRC 200.

- (13) The same fuel type for heating, cooling and water heating as used in the Rated Home.
- (14) One each heating, cooling and hot water system of the same type as in the Rated Home except as required by the exceptions in Section B.4.a.16. of these Guidelines;
- (15) If the Rated home contains multiple heating, cooling or water heating systems using different fuel types, then the applicable Reference Home 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.
- (16) The minimum NAECA efficiency in effect on January 1, 1992 for the same type of HVAC equipment found in the Rated Home except that the efficiencies given in Table 5 will be assumed when;
 - (a) A type of device not covered by NAECA is found in the Rated Home;
 - (b) The Rated Home is heated by electricity using a device

- other than an air source heat pump; or
- (c) The Rated Home does not contain one or more of the required HVAC equipment systems.

Table 5. Reference Home Equipment Efficiencies

Rated Home Fuel	Function	Reference Home Device
Electric	Heating	6.8 HSPF Air Source Heat Pump
Non Electric Warm Air Furnace	Heating	78% AFUE Gas Furnace
Non Electric Boiler	Heating	80% AFUE Gas Boiler
Any Type	Cooling	10 SEER Electric Air Conditioner

- (17) The sizing of HVAC equipment determined in accordance with accepted engineering practice for that equipment and fuel type.
- (18) A distribution system efficiency of 0.80, which is to be multiplied by the equipment efficiencies determined under Section B.4.a.15. of these Guidelines.
- (19) The efficiency of the water heater;
- (a) For Rated Homes with a storage type water heater, the minimum NAECA Energy Factor in effect on January 1, 1992 for the fuel type and size found in the Rated Home;
- (b) For Rated Homes with a non-storage type water heater, the minimum NAECA Energy Factor in effect on January 1, 1992 is used to provide domestic hot water in the Rated Home.
- (c) For Rated Homes without water heaters, the minimum NAECA Energy Factor in effect on January 1, 1992 for a 40 gallon storage type water heater using the same fuel as the predominant heating fuel type in the Rated Home shall be used for the purpose of calculating the HERS Score. (Note: This energy use may be excluded from the purchased energy cost estimate for the Rated Home.)
- (20) An annual average air change rate as determined from normalized building leakage (nL) using Equation 6.

Equation 6: $ach = nL \times W$

where:

ach = average annual air changes per hour

nL (normalized leakage) = 0.57 for the Reference Home.

W = Weather factor from W Tables in ASHRAE Standard 136 for the site most climatologically representative of the Rated Home's location.

- (21) An internal mass for furniture and contents of 8 pounds per square foot of floor area;

- (22) Only the structural mass and associated heat capacitance calculated as follows:
 - (a) For masonry floor slabs, as found in the Rated Home;
 - (b) For masonry basement walls, as found in the Rated Home, but with any basement wall insulation as required under paragraph (3) assumed to be located on the interior side of the basement walls;
 - (c) For walls other than basement walls, for ceilings, floors, and interior partition walls, using equivalent areas to the Rated Home assuming light frame construction.

5. **Minimum rated features.**

- a. All HERS providers shall calculate the estimated annual purchased energy consumption for heating, cooling and water heating set forth in Section B.1 of these Guidelines using the energy loss and gain associated with the minimum rated features set forth in Table 7.
- b. For existing homes, the envelope thermal characteristics of building elements 1 through 7 set forth in Table 7 are determined by site observation.
- c. If data for the minimum rated features set forth in paragraph (b) of this Section can not be obtained by observation or without destructive disassembly of the home, all HERS providers shall use default values. The default values are determined from the following sources listed in the preferential order of use:
 - (1) for manufactured homes, available manufacturer's data;
 - (2) current and historical local building practices; or
 - (3) current and historical local building codes.
- d. Default values set forth in paragraph (c) of this section shall be established or approved by the Vermont Department of Public Service for all HERS providers operating in Vermont.
- e. For existing homes, the determination of air leakage and duct leakage values set forth as building elements 10 and 11 in Table 7 are determined by data collected on site using the following procedures listed in preferential order of use:
 - (1) current on-site diagnostic tests conducted in accordance with nationally accepted pressurization test standards; or
 - (2) observations of the condition of the building and duct system made by the HERS provider. Based on these observations values used will be;
 - (a) for envelope air leakage, a minimum normalized leakage rate of $nL = 0.67$, where nL may be converted to an air change rate using Equation 6 of Section B.4.a(20) to compute average annual air changes per hour(ach); and
 - (b) for distribution system efficiency, default values in accordance with Table 6, below.
 - (3) The energy efficiency of the mechanical equipment set forth as building elements 12 through 14 in Table 7 is determined by data collected on site using the following sources listed in preferential

order of use:

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

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

where:

Eff,rated = annual efficiency to use as input to the rating

Eff,listed = listed annual efficiency by manuf. Or directory

Es,measured = measured steady state efficiency of system

Es,listed = manufacturer's listed steady state efficiency,
under the same operating conditions found
during measurement

- (b) name plate data;
(c) manufacturer's data sheet; or
(d) equipment directories.

Table 6. Default Values¹ for Distribution System Efficiencies

Distribution System Configuration and Condition:	Forced Air Systems		Hydronic Systems ²	
	Heating	Cooling	Heating	Cooling
<i>Observable leakage pathways</i> ³ with distribution system components located in <i>unconditioned</i> space	0.70	0.70		
<i>Observable leakage pathways</i> with entire distribution system located in <i>conditioned</i> space ⁴	0.75	0.75		
Distribution system components located in <i>unconditioned</i> space	0.80	0.80	0.95	0.95
Entire distribution system located in <i>conditioned</i> space	0.85	0.85	1.00	1.00
<i>Proposed</i> ⁵ “leak free” with entire air distribution system located in the <i>conditioned</i> space	1.00	1.00		
<i>Proposed</i> “leak free” air distribution system with components located in the <i>unconditioned</i> space	0.95	0.95		
“Ductless” ⁶ systems	1.00	1.00		

Table 6 Notes:

1. *Default values* given by this table are for distribution systems that have been visually inspected only, and which meet MEC ‘93 minimum requirements for duct system insulation. Visual inspection is **not** the recommended method of determining forced air distribution system leakage. The recommended and preferred method of determining forced air distribution system leakage is through pressurization testing accomplished in accordance with Section B.5.e.(1) of this Guideline.

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

3. *Observable leakage pathways* shall mean that elements of the air

distribution system (including joints, seams, connection flanges, collars, boots, panned ducts, construction cavities used as airflow pathways, and other like system components) can be visually determined to contain one or more flaws through which unconditioned air may be forced into or out of the designated air duct system.

4. *Entire system in conditioned space* shall mean that no component of the distribution system, including the air handler unit, is located outside of the plane of the conditioned space boundary. Conditioned space shall mean any building space directly or indirectly heated or cooled in accordance with the definitions provided in section A.3. of this Guideline. Any other air distribution system condition results in *system components located in unconditioned space*.

5. *Proposed “leak free”* shall mean *substantially leak free* as defined by the 1998 IECC (International Energy Conservation Code) to be a leakage rate of not more than 5% of the rated fan flow rate at a pressure differential of 25 Pascal across the entire system, including the manufacturer’s air handler enclosure. This ***proposed condition is reserved for Projected Ratings*** and must be specified as the required performance in the construction documents. This proposed condition ***requires confirmation through field testing*** of installed systems.

6. Ductless systems may have forced air flow across a coil but shall not have any ducted air flows external to the manufacturer’s air handler enclosure.

- f. If the Rated Home does not utilize at least one each heating, cooling and hot water system, the Reference Home equipment efficiencies as specified in section B.4.a.(16) shall be assumed for the relevant missing system(s) in the Rated Home for the purposes of calculating the rating.
- g. If the Rated Home utilizes multiple heating, cooling or hot water systems, the operating conditions specified in Section B.6 of these Guidelines shall be used for each system and the relevant purchased energy consumption calculations shall be appropriately weighted by system capacity in accordance with the loads distribution as calculated by accepted engineering practice for that equipment and fuel type.
- h. If information on the energy efficiency of mechanical equipment cannot be determined from the sources listed in paragraph (3) of this section, the values set forth in Tables 8 and 9 shall be used.
- i. Any HERS provider may base annual purchased energy consumption estimates for the Rated Home on additional features if the HERS provider’s energy analysis tool is capable of doing so.

TABLE 7.-- Minimum Rated Features

Building element	Minimum rated features
1. Floor/Foundation Assembly.	Construction type (slab-on-grade, crawl space; basement), insulation (edge, under slab, cavity, sheathing), vented or unvented (crawl space), capacitance (if slab or basement receives appreciable solar gain).
2. Walls	Construction type, insulation value (cavity, sheathing); capacitance, color (light, medium, or dark).
3. Roof/Ceiling Assembly	Construction type, insulation value (cavity, sheathing), roof color (light, medium, or dark).
4. Rim Joist.....	Insulation value (cavity, sheathing).
5. Doors	Construction type, insulation value.
6. Windows.....	Construction type, orientation, U-value (of complete assembly), solar heat gain coefficient, shading.
7. Skylights.....	Construction type, orientation, tilt, U-value (of complete assembly), heat gain coefficient, shading.
8. Passive Solar System (Direct Gain system).....	Solar type, collector type and area, orientation, tilt efficiency, storage tank size, pipe insulation value.
9. Solar Domestic Hot Water Equipment	System type, collector type and area, orientation, tilt, efficiency, storage tank size, pipe insulation value.
10. Air Leakage	Air leakage measurement type (default estimate, blower door test, tracer gas test), volume of conditioned space.
11. Distribution System.....	System type, location, insulation value (duct and pipe), air leakage measurement type (default estimate, duct blaster, pressure pan threshold, blower door subtraction).
12. Heating Equipment.....	Equipment type, location, efficiency (AFUE, HSPF).
13. Cooling Equipment	Equipment type, location, efficiency (SEER, COP).
14. Domestic Hot Water Equipment	Equipment type, location, energy factor or seasonal efficiency, extra tank insulation value, pipe insulation value.
15. Control Systems	Thermostat type.

TABLE 8.– Default Values for Mechanical System Efficiency (Age-based)

Mechanical Systems	Units	Pre-1960	1960-69	1970-74	1975-83	1984-87	1988-91	1992 to present
Heating:								
Gas Furnace	AFUE	0.60	0.60	0.65	0.68	0.68	0.76	0.78
Gas Boiler	AFUE	0.60	0.60	0.65	0.65	0.70	0.77	0.80
Oil Furnace or Boiler	AFUE	0.60	0.65	0.72	0.75	0.80	0.80	0.80
Air-Source Heat Pump.....	HSPF	4.50	4.50	4.70	5.50	6.30	6.80	6.80
Ground-Water Geothermal Heat Pump	COP	2.70	2.70	2.70	3.00	3.10	3.20	3.50
Ground-Coupled Geothermal Heat Pump	COP	2.30	2.30	2.30	2.50	2.60	2.70	3.00
Cooling:								
Air-Source Heat Pump.....	SEER	5.00	6.10	6.50	7.40	8.70	9.40	10.00
Ground-Water Geothermal Heat Pump	EER	10.00	10.00	10.00	13.00	13.00	14.00	16.00
Ground-Coupled Geothermal Heat Pump	EER	8.00	8.00	8.00	11.00	11.00	12.00	14.00
Central Air Conditioner.....	SEER	5.00	6.10	6.50	7.40	8.70	9.40	10.00
Room Air Conditioner	EER	5.00	6.10	6.10	6.70	7.70	8.10	8.50
Water Heating:								
Storage Gas	EF	0.47	0.47	0.47	0.49	0.55	0.56	0.56
Storage Oil	EF	0.47	0.47	0.47	0.48	0.49	0.54	0.56
Storage Electric	EF	0.79	0.80	0.80	0.81	0.83	0.87	0.88

TABLE 9.– Default Values for Mechanical System Efficiency (not Age-based)

	Units	Rating
Heating :		
Gas Wall Heater (Gravity)	SE	0.65
Gas Floor Furnace	SE	0.60
Gas Water Heater (Space Heating).	AFUE	0.75
Electric Furnace.....	HSPF	3.413
Electric Radiant	HSPF	3.413
Heat Pump Water Heater (Space)	HSPF	5.11
Electric Water Heater (Space).....	HSPF	2.73
Cooling:		
Electric Evaporative Cooling	EER	30
Gas Absorption Cooler	COP	0.40
Water Heating:		
Heat Pump	COP	2.00
Instantaneous Electric	EF	0.87
Instantaneous Gas.....	EF	0.75
Solar (Use SRCC Adjustment Procedures)	EF	2.00

6. Operating condition assumptions .

- a. All HERS providers shall estimate the annual purchased energy consumption for heating, cooling and hot water for both the Rated Home and the Reference Home using the following assumptions–
 - (1) Temperature control set points for heating and cooling of 68° F and 78°F, respectively;
 - (2) Where programmable offsets are available in the Rated Home, 5° F temperature control point offsets with an 11 p.m. to 7 a.m. schedule for heating and a 9 a.m. to 3 p.m. schedule for cooling, and with no offsets assumed for the Reference Home;
 - (3) Internal heat gains from lights, people and equipment of 72,000 Btu/day for detached homes and 36,000 Btu/day for attached homes;
 - (4) When calculating annual purchased energy for cooling, internal

- latent gains assumed as 0.20 times sensible internal heat gains;
- (5) Estimated hot water usage based on Equation 7.

Equation 7: Gallons/day = 30 gallons+(10 gallons* number of bedrooms).

- (6) The climatologically most representative TMY or equivalent climate data, which may be interpolated between climate sites if interpolation is established or approved by the accrediting body for all HERS providers operating within Vermont.
- (7) Corrections for climate conditions and mis-sizing of equipment, using correction factors to HSPF, SEER and AFUE that are established by the Vermont Department of Public Service for all HERS providers operating within Vermont.
- (8) Local residential energy or utility rates that–
- (a) Are revenue-based and include customer service and fuel charges; and
 - (b) Are updated at least annually.
7. **Non-rated energy consuming devices.**
- a. Consistent with Section B.3.c.(1) and (2) of these Guidelines all HERS providers shall calculate and report the annual purchased energy consumption and energy cost for the operation of all non-rated energy consuming devices in the Rated and Reference Homes. Actual efficiency of these devices is not considered and usage estimates are based on Table 10.

TABLE 10.–Annual Energy Use for Non-Rated Features

End use	Units/year	Energy estimate	Applicability
Ceiling Fan	KWh	220/ea	If present.
Dishwasher	KWh	299/per cooking area	If present, or if space is dedicated for DW.
Dryer, electric	KWh	875/ea	If present, or if 220V wiring is present @ dryer location
Dryer, gas	Therms KWh	60/ea 100/ea	If present, or if gas piping is present @ dryer location. a
Lights	KWh	940	All homes.
Microwave Oven- built-in	KWh	191/per cooking area	If permanently installed.
Miscellaneous Plug Loads	KWh	500	All homes.
Pool Pump	KWh	1700/ea	If present
Range/Oven Combo- electric	KWh	450/per cooking area	If present, or if 220V wiring is present @ range location.
Range/Oven Combo- gas w/pilot	Therms	44/per cooking area	If present, or if gas piping is present @ range location
Range/Oven Combo- gas w/o pilot	Therms	22/per cooking area	If present.
Refrigerator	KWh	1150	Each one present.
Television	KWh	720	All homes.
Washer, clothes	KWh	99/ea	If present, or facilities present for washer.
Well pump	KWh	288/ea	If present.

8. Projected Ratings for to-be-built or to-be-improved homes.

- a. A HERS provider may calculate the Projected Rating of a to-be-built or to-be-improved home based on architectural drawings with material, mechanical and electrical specifications for a to-be-built home, or based on a site audit for a to-be-improved home; and by:

(1) Using either the envelope leakage rate specified as the required

performance by the construction documents, the site-measured envelope leakage rate, or a default value for normalized leakage of $nL = 0.67$, where nL may be converted to an air change rate using Equation 6 of Section B.4.a(20) to compute average annual air changes per hour(ach);

- (2) Using either the distribution system efficiency specified as the required performance by the construction documents, the site-measured distribution system efficiency, or a default distribution system efficiency value from Table 6; and
 - (3) Using the planned location and orientation of the proposed home, or if the proposed orientation is unknown, calculating ratings for the home facing each of the four cardinal directions, north, south, east and west, and using the lowest rating score as the Projected Rating.
- b. Upon completion of construction and verification of the proposed specifications, all rated features of the home shall be confirmed using site inspections and envelope air leakage rates and distribution system efficiencies derived from on-site diagnostic tests conducted in accordance with Section B.5.e.(1) of these Guidelines, and the actual orientation of the home.

C. REVISION OF TECHNICAL GUIDELINES

1. Periodic review of technical Guidelines

The Vermont Department of Public Service may review and update these Technical Guidelines as warranted, for example, due to changes in the law, technological innovations, or specific proposals for review or modification.

2. Submission of proposals to change Technical Guidelines:

- a. Proposals to change these Technical Guidelines may be submitted in writing, at any time, to the Vermont Department of Public Service.
- b. Proposals to change these Technical Guidelines shall include the following:
 - (1) Identification of the proposal to change, including the following minimum information:
 - (a) Proponent(s) full name(s),
 - (b) Organizational affiliation(s) or representation(s),
 - (c) Full mailing address(es),
 - (d) Daytime phone number(s),
 - (e) Signature of primary proponent, and
 - (f) Date
 - (2) Specific revisions to the Technical Guidelines in a format that clearly identifies the manner in which the Technical Guidelines are to be altered (ie. underline/strikeout format or equivalent). Any proposal to change that does not include proposed alteration(s) shall be rejected and returned to the proponent.
 - (3) Substantive reason(s) or justification for each proposed change. The lack of substantive justification for a proposed change may result in the denial of the proposal.

- (4) Supporting documentation that may be needed for the reasoned evaluation of the proposal.