RESNET® RESIDENTIAL ENERGY SERVICES NETWORK

Setting the Standards for Home Energy Efficiency

# Minutes of RESNET Board of Directors Meeting

**July 16, 2020**

| Members Present | Members Absent | Staff Present |
| --- | --- | --- |
| Dave Bell | Jim Amorin | Steve Baden |
| Thiel Butner | Jacob Atalla | Emma Bennett |
| Philip Fairey | David Beam | Valerie Briggs |
| Matt Gingrich | Roy Honican | Scott Doyle |
| Emelie Cuppernell Glitch | | Laurel Elam |
| David Goldstein | | Cardice Howard |
| John Hensley | | Ryan Meres |
| Mark Johnson | | |
| Cy Kilbourn | | |
| Abe Kruger | | |
| Paulette McGhie | | |
| Chris McTaggart | | |
| Clayton Morris | | |
| Curt Rich | | |
| Brian Shanks | | |
| Clayton Traylor | | |

## Call to Order

Matt Gingrich, RESNET Board President, called the meeting to order at 2:02 p.m. Eastern Time.

## Roll Call

Philip Fairey, RESNET Board Secretary, called the roll. A quorum was present.

## Approve Agenda

Brian Shanks made a motion to approve the agenda that was sent prior to the meeting. Philip Fairey seconded the motion. Motion approved by a voice vote.

## RESNET Anti-Trust Policy

Curt Rich reminded the RESNET Board of the RESNET Anti-Trust Policy that was sent prior to the meeting.

**Approve Draft Minutes of May 22, 2020 RESNET Board Meeting**

Philip Fairey made a motion to approve the draft minutes of the May 22, 2020 board meeting that were sent prior to the meeting. Cy Kilbourn seconded the motion. Motion approved by a voice vote.

**Decision on the 2021 RESNET Building Performance Conference**

Prior to the Board meeting a briefing paper (Attachment A) on the issue was distributed to Board members.

Emma Bennett presented on the option to move the RESNET 2021 Conference and options to move it to a virtual platform. Staff recommendation, based on the cost benefit analysis and network survey, was to move 100% virtual.

Board members discussed options for moving virtual and ways to make it valuable to attendees. Emma Bennett will start a discussion in DirectorPoint to continue discussion and options.

Emelie Cuppernell Glitch made the motion to move the 2021 Conference to virtual. Clayton Morris seconded the motion. Motion approved by unanimous voice vote.

**Decision to make the Fall 2020 RESNET Board Virtual Meeting Open to Public**

Cardice Howard reviewed the briefing paper Fall 2020 RESNET Board Virtual Meeting Open to Public (Attachment B) and recommended opening the Board meeting.

There was no motion or second for staff's proposal.

Board members discussed the options, and whether or not the meeting would need to be recorded for internal use. Curt Rich recommended in lieu of an open meeting, that the RESNET board of directors host a townhall following the meeting.

Curt Rich made a motion to have a one hour board townhall following the board meeting in October. Philip Fairey seconded the motion. Motion passed by voice vote.

**Adoption of RESNET Publication No. 001 -20 "Procedures for Certifying Residential Energy Efficiency Tax Credits"**

Steve Baden reviewed the latest draft publication that includes Paulette McGhie edits, that was sent prior to the meeting, and was attached to the meeting notice (Attachment C).

Brian Shanks asked with the 310 adoption, if builders would have to use 310 commissioning practices to qualify for the 45L tax credit, or if it was voluntary. Philip stated that it was not mandatory, technically, but benefits the builder and would not penalize the homes if it is not done. It would only offer credits if the HVAC installation is in accordance with Grades I or II.

Board discussed RESNET's stance for raters submitting 45L tax credit documents without the proper verification. Steve Baden encouraged discussion to take place on DirectorPoint to address the larger issue.

Dave Bell made a motion to adopt the amended Publication No. 001-20. Cy Kilbourn seconded the motion. Motion passed by voice vote. Thiel Butner and Brian Shanks abstained.

**Consideration of Recommendation of the RESNET Software Consistency Committee to Amend its Charter**

Neal Kruis presented to the board the amended to the RESNET Software Consistency Committee Charter to allow voting members to be a part of the committee (Attachment D).

Philip Fairey made a motion to adopt the amended RESNET Software Consistency Committee charter. Thiel Butner seconded the motion. Motion passed by voice vote.

**New Business**

Matt Gingrich opened the floor for new business.

**Adjournment**

Abe Kruger made a motion to adjourn. Meeting was adjourned at 3:35 p.m. Eastern Time.

**Respectfully Submitted,**

Philip Fairey, Secretary

# Attachment A

RESNET
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Setting the Standards for Home Energy Efficiency

# RESNET Board Briefing Paper on RESNET 2021 Conference Options July 2, 2020

With the COVID-19 pandemic creating a "new normal" on travel and social interactions, RESNET staff has been continuously reviewing the options on how to adapt our conference for February 2021.

The United States is seeing a continued increase of COVID-19 cases. Atlanta, GA (location of the 2021 conference) is currently seeing their highest increase in case numbers to date. Experts are also predicting a second wave of the virus in the winter of 2020. Clearly there is a need to take a look at how the 2021 RESNET Conference should be conducted.

RESNET staff has now garnered enough information on conference options and completed the cost/benefit analysis to make a recommendation to the RESNET Board.

## PROJECTED 2021 ATTENDANCE IMPACT

The social distancing and wearing masks measures are expected to remain in place for the foreseeable future, and into next year. It is projected that the following changes would take place with an in-person conference next February:

- Reduced attendance du to:
    - Restricted travel measures by government or companies
    - General unease of attendees to travel and attend events or be in large groups
    - Economic downturn to prohibit attendees to afford travel
- Restriction of networking opportunities at the conference due to social distancing measures
- Limited seating in the general and breakout sessions at the conference due to social distancing
- Reduced exhibit hall numbers
- Increased moral and legal liability of RESNET if attendees get sick
- Severely limited social events (receptions and after hours networking)

- Moving from the traditional buffets to boxed lunches

All of the above activities in the past has made the annual RESNET Conference popular with its community and has defined the conference's brand. Because of the above restrictions and changes to the factors of the event that makes the RESNET Conferences great, staff fears that the reputation of this event could be at risk for following years if we do not have a quality product that conference

- attendees have grown to expect.conference due to social distancing
- Reduced exhibit hall numbers
- Increased moral and legal liability of RESNET if attendees get sick
- Severely limited social events (receptions and after hours networking)
- Moving from the traditional buffets to boxed lunches

All of the above activities in the past has made the annual RESNET Conference popular with its community and has defined the conference's brand. Because of the above restrictions and changes to the factors of the event that makes the RESNET Conferences great, staff fears that the reputation of this event could be at risk for following years if we do not have a quality product that conference attendees have grown to expect.

A survey is currently out to the RESNET network to determine how RESNET stakeholders feel about how we should proceed. Results will be available by July 11, 2020.

# INTRODUCING A NEW NORMAL – VIRTUAL CONFERENCE

Due to health and economic concerns, virtual conferences are increasingly being conducted over the traditional in-person gatherings. To date such industry events as the National Building Performance Conference, the North American Passive House Conference and the ACEEE Summer Study is being conducted virtually.

With this trend the conference technology platforms have dramatically improved. It is really exciting how virtual conference platforms can capture the experience of an in-person conference.

RESNET staff has tracked a number of conferences that switched from in-person to virtual during the pandemic. Anecdotal analysis indicates that attendance have actually increased for virtual conferences over the traditional in-person conference. This makes sense in that getting the educational opportunities virtually will reduce travel costs for attendees and exhibitors as well address the health and budget concerns.

To give the Board a sense of a virtual conference, the following are links to videos for platforms for the conference and exhibiting that we are currently considering.

- Vario demo: https://vimeo.com/420887209/d3366db022

- 3D Expo demo: https://youtu.be/FkEeeM1pfD8

## 2021 CONFERENCE OPTIONS

RESNET staff has developed and reviewed three possible options to move forward in 2021: b

1. 100% Virtual – move the RESNET Conference completely virtual for RESNET 2021.
2. Hybrid – offer an in-person event along with a virtual component so attendees can choose to attend in Atlanta or from home.
3. In-person – continue with the plan to have the conference in Atlanta with adjustments based on public health guidelines at that time.

For these options, staff has undertook a cost/benefit analysis to estimate the profit and loss of each option based on staff analysis and research of other events and statistics from previous RESNET conferences.

## COST/BENEFIT ANALYSIS OVERVIEW

Please note that the cost/benefit analysis is not a full conference budget, but a projection on what cost might look like based on necessary expenses for each option. The following is the grand total of income, expenses, and savings of the three options.

1. **100% Virtual Conference -** $798,000.00 (Net Income + Savings Total)
2. **Hybrid Conference** – (- $65,000)
3. **In-person Conference** – (- $160,000)

Based on our research and analysis, RESNET staff recommends that we move forward with a completely virtual option. See the subsequent pages to review the detailed cost/benefit analysis for each option. This decision will need to be made by August 1, 2020, so that RESNET staff can negotiate and make the final arrangements with the Atlanta hotel and avoid additional penalties. A prompt decision will also allow staff time to move forward with promotion, recruiting sponsors, opening up session proposals, etc.

## Virtual Cost Benefit/Analysis

| INCOME | | | *Notes* |
|---|---|---|---|
| Attendee Revenue | $ | 445,000.00 | 30% increase attendance based on the average 2019-2020 conference attendance |
| Sponsor Revenue | $ | 150,000.00 | Based on 2019-2020 sign-up average, no change |

| | | |
|---|---|---|
| **Income Total** | $ | 595,000.00 |
| | | |
| Virtual Platform | $ | 40,000.00 |
| Hotel Cancellation Fee | $ | 49,500.00 |
| Professional Services | $ | 25,000.00 |
| Promotion | $ | 20,000.00 |
| | | |
| **Expenses Total** | $ | 134,500.00 |
| **NET INCOME** | **$** | **460,500.00** |
| | | |
| Hotel Fees | $ | 298,000.00 |
| Staff Travel | $ | 10,000.00 |
| Printing/Shipping | $ | 1,000.00 |
| Professional Services | $ | 25,000.00 |
| Liability & COVID 19 Measures | $ | 3,000.00 |
| | | |
| **Savings Total** | $ | 337,000.00 |
| | | |
| **GRAND TOTAL (NET Income + Savings Total)** | **$** | **797,500.00** |

## OPTION 2 – Hybrid Conference

This would be the most expensive option, considering RESNET would have to pay both venue costs, virtual platform costs, additional staffing, and increase in AV at the hotel to record and upload sessions into the platform.

If attendees have the option to choose between attending an in-person or hybrid for 2021, we may see a large attendance decrease in Atlanta, GA and would be liable for attrition costs with the hotel. We do not predict this being a problem for future conference, just due to circumstances with the pandemic. Assuming a 60% decrease in face-to-face attendance, plus capturing attendees on the virtual platform, we can predict that attendance would stay constant as previous years.

Promoting both a virtual and hybrid conference could cause confusion. We would also likely see a decrease in sponsors and exhibitors because companies may have restrictions on travel, and companies may not have the bandwidth to manage a virtual and in-person booth.

| Hybrid Conference Cost/Benefit Analysis | | | | |
|---|---|---|---|---|
| **INCOME** | | | | ***Notes*** |
| | Attendee Revenue | $ | 342,185.00 | Average 2019-2020, no change |
| | Sponsor Revenue | $ | 75,000.00 | Based on 2019-2020 Average, 50% decrease |
| | Income Total | $ | 417,185.00 | |
| **EXPENSES** | | | | |
| | Virtual Platform | $ | 20,000.00 | Session platform |
| | Audio Visiual (AV) | $ | 50,000.00 | AV to record and upload sessions |
| | Hotel Fees | $ | 298,000.00 | Based on 2020 costs / Sleeping rooms, F&B, AV, etc. |
| | Staff Travel | $ | 10,000.00 | Based on 2020 costs |
| | Printing/Shipping | $ | 1,000.00 | |
| | Professional Services | $ | 50,000.00 | Expo Furnishing, Registration desk, Signage etc. |

| | | | |
|---|---|---|---|
| Staffing | $ | 30,000.00 | Would require additional staffing to manage both |
| Promotion | $ | 20,000.00 | Double amount of 2020 |
| Liability & COVID 19 Measures | $ | 3,000.00 | Legal fees for waiver, PPE for attendees |
| Expenses Total | $ | 482,000.00 | |
| **NET INCOME** | **$** | **-64,815.00** | |

## OPTION 3 - In-person

Without any virtual option, we predict that we will see around a 60% decrease in attendance for RESNET 2021. This would result be a significant loss in revenue and negative effect on the 2021 RESNET Budget. It can be assumed that companies may still have travel restrictions and/or budget constraints due to the COVID-19 pandemic, therefore we anticipate a 50% decrease in sponsorship.

RESNET is also at risk of not filling the room blocks. Although the hotel has offered the flexibility to adjust our room block closer to the event, we would still be liable of up to $100,000 in attrition (400 room nights).

| In-Person Cost/Benefit Analysis | | | | |
|---|---|---|---|---|
| **INCOME** | | | | ***Notes*** |
| | Attendee Revenue | $ | 136,874.00 | 60% decrease average 2019-2020 |
| | Sponsor Revenue | $ | 75,000.00 | Based on 2019-2020 Average - 50% reduction |
| | TOTAL | $ | 211,874.00 | |
| **EXPENSES** | | | | |
| | Hotel Fees | $ | 298,000.00 | Based on 2020 costs / Sleeping rooms, F&B, AV, etc. |
| | Staff Travel | $ | 10,000.00 | Based on 2020 costs |
| | Printing/Shipping | $ | 1,000.00 | |
| | Professional Services | $ | 50,000.00 | Expo Furnishing, Registration desk, Signage etc. |
| | Promotion | $ | 10,000.00 | Based on 2020 costs |
| | Liability & COVID 19 Measures | $ | 3,000.00 | Legal fees for waiver, PPE for attendees |
| | Expenses Total | $ | 372,000.00 | |
| | **NET INCOME** | **$** | **-160,126.00** | |

# Attachment C

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# Procedures for Accrediting Software Tools for Residential Energy Efficiency Tax Credits

RESNET Publication No. 001-20

July 16, 2020

*Published by:*

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

# Procedures for Accrediting Software Tools for Residential Energy Efficiency Tax Credits

RESNET Publication No. 001-20

July XX, 2020

## *1. Purpose*

This publication provides procedures for accrediting residential energy efficiency software tools used for calculating new dwelling unit energy savings for the purpose of federal tax credit qualification.

## *2. Scope*

This procedure applies to the accreditation of residential energy savings for tax credit qualification for new attached and detached dwellings units in buildings that are three stories or less above grade level. This procedure employs a set of standard operating conditions representative of typical dwelling units. As such, it may not accurately reflect the energy use of dwelling units that depart from these standard operating conditions. This procedure does not apply to dwelling units in buildings that are greater than three stories above grade.

## *3. Accreditation of Tax Credit Software Tools*

In order to ensure the accuracy of software tools used to calculate energy savings in new dwelling units, software tools seeking accreditation as tax credit qualification tools shall comply with Sections 3.1 through 3.3.

**3.1 Tax Credit Reference Home Rule Set.** The technical specifications defined in Appendix A of this document shall serve as the rule set for configuration of the Tax Credit Reference Home and the Qualifying Home for determination of tax credit qualification. Software tools shall adhere to this rule set.

**3.2 Suite of Software Verification Tests.** Software tools shall be subjected to verification testing in accordance with Sections 3.2.1 through 3.2.4 and shall demonstrate results within the acceptance criteria. Where applicable, simulation results shall be generated using TMY3 site 724660, Colorado Springs Muni AP (for heating related tests) and TMY3 site 723860, Las Vegas McCarran Intl AP (for cooling related tests) and not the original TMY data referenced by ASHRAE Standard 140.

ANSI/ASHRAE Standard 140, Class II, Tier 1 Tests. ASHRAE Standard 140, Class II Tests were developed from the HERS BESTEST[1] for testing the accuracy of simulation software for predicting building loads. The ANSI/ASHRAE

**3.2.1** of simulation software for predicting building loads. The ANSI/ASHRAE Standard 140, Class II, Tier 1 test procedure has been adopted by RESNET and is a requirement for all software tools to be accredited. Acceptance criteria for this suite of tests shall be as specified in Appendix B.

**3.2.2** Auto-generation of the Tax Credit Reference Home – This test verifies the ability of the software tool to automatically generate the Tax Credit Reference Home. See Appendix C for the test cases and acceptance criteria for the auto-generation test suite.

**3.2.3** RESNET HVAC Tests – RESNET has developed a series of tests that test the consistency with which software tools treat HVAC equipment, including furnaces, air conditioners, and air source heat pumps. See Appendix D for the test cases and the established acceptance criteria for this test suite.

**3.2.4** Duct Distribution System Efficiency Tests – This test measures the accuracy with which software tools calculate air distribution system losses. ASHRAE Standard 152 results are used as the basis for the test suite acceptance criteria. See Appendix E for the test cases and acceptance criteria for this test suite.

### 3.3 Process for Accrediting Software Tools

The accreditation process provides a suite of verification tests to determine whether software tools conform to the verification criteria for each test. The software developer shall be required to submit the test results, test runs, and the software tool with which the tests were conducted. This information may be released for review by any party, including the Treasury Department and competing software developers.

## *4.* References

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." Residential Energy Services Network, Oceanside, CA.

ASHRAE Standard 140-2017, "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs." American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA, 2012.

ASHRAE, Standard 152-2004, "Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distributions Systems." American

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

Society for Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

ANSI/CRRC S100-2016, “Standard Test Methods for Determining Radiative Properties of Materials,” Cool Roof Rating Council, Oakland, CA. www.coolroofs.org

ICC, 2006, “2006 International Energy Conservation Code.” International Code Council, Country Club Hills, IL.

ICC, 2018, “International Residential Code for One- and Two-Family Dwellings.” International Code Council, Country Club Hills, IL.

# Appendix A

Software Tool Accreditation and Rule Set
For Dwelling Unit Federal Tax Credit Qualification

*Introduction*

This software tool accreditation and rule set publication consists of three principal sections: Section 1 provides standards for the accreditation of software tools used for tax credit qualification; Section 2 specifies the method by which energy savings are determined; and Section 3 (the "rule set") provides the required standards for the configuration, simulation, analysis and testing (where applicable), of the Tax Credit Reference Home and the Qualifying Home.

## *1 Software Tools for Tax Credit Qualification*

**1.1 Minimum software tool capabilities.** Calculation procedures used to qualify dwelling units for tax credits shall be computer-based software tools capable of calculating the annual energy consumption of the Tax Credit Reference Home and the Qualifying Home and shall include the following minimum capabilities:

a. Computer generation of the Tax Credit Reference Home using only the input for the Qualifying Home. The calculation procedure shall not allow the user to directly modify the building component characteristics of the Tax Credit Reference Home.
b. Calculation of the HVAC system installation quality Grade in accordance with ANSI/RESNET/ICC 301-2019, Addendum B-2020.
c. Calculation of dwelling unit, single-zone sizing for the heating and cooling equipment in the Tax Credit Reference Home in accordance with ANSI/RESNET/ICC 301-2019.
d. Calculations that account for the indoor and outdoor temperature dependencies and the part load performance of heating, ventilating and air conditioning equipment based on climate and equipment sizing.

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

a. Address of the Qualifying Home;
b. Documentation of all building component characteristics of the Qualifying Home.
c. Documentation of the estimated annual energy consumption for heating and cooling for both the Tax Credit Reference Home and the Qualifying Home, the calculated energy reduction percentage for the Qualifying Home relative to the Tax Credit Reference Home and the calculated percentage saving due to envelope improvements relative to the Tax Credit Reference Home;
d. Name and signature of individual certified to complete the qualification report;
e. Name and version of the accredited tax credit qualification software tool used to perform the qualification analysis.

**1.3 Software tool accreditation.** Software tool accreditation shall be based on verification in accordance with Sections 1.3.1 through 1.3.4.

**1.3.1 ANSI/ASHRAE Standard 140, Class II, Tier 1 Tests.** ASHRAE Standard 140, Class II Tests were developed from the HERS BESTEST[2,3] for testing the accuracy of simulation software for predicting building loads. The ANSI/ASHRAE Standard 140, Class II, Tier 1 test procedure has been adopted by RESNET and is a requirement for all software tools to be accredited. Acceptance criteria for this test suite shall be as specified in Appendix B.

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

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

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

## 2 Computation of Energy Savings

**2.1** The energy loads for heating and cooling in the Qualifying Home shall be normalized to account for the differences in improvement potential that exist across equipment types using the following formula:[34]

nMEUL = REUL * (nEC_x

/EC_r) where:

nMEUL = normalized Modified End Use Loads (for heating or cooling) as computed using accredited simulation tools.
REUL = Tax Credit Reference Home End Use Loads (for heating or cooling) as computed using accredited simulation tools.
EC_r = estimated Energy Consumption for Tax Credit Reference Home's end

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

[3] Fairey, P., J. Tait, D. Goldstein, D. Tracey, M. Holtz, and R. Judkoff, "The HERS Rating Method and the Derivation of the Normalized Modified Loads Method." Research Report No. FSEC-RR- 54-00, Florida Solar Energy Center, Cocoa, FL, October 11, 2000. Available online at: https://publications.energyresearch.ucf.edu/wp-content/uploads/2018/06/FSEC-RR-54-00.pdf

uses (for heating, including auxiliary electric consumption, or cooling) as computed using accredited simulation tools.

and where:

$$nEC\_x = (a * EEC\_x - b) * (EC\_x * EC\_r * DSE\_r) / (EEC\_x * REUL)$$

where:

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

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

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

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

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

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

DSE_r = REUL/EC_r * EEC_r

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

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

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

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

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

Table 2.1 Coefficients 'a' and 'b'

| Fuel Type and End Use | a | b |
|---|---|---|
| Electric space heating | 2.2561 | 0 |

Table 2.1 Coefficients 'a' and 'b'

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

*Such as natural gas, LP, fuel oil

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

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

## 3 Rule Set for Configuration of the Tax Credit Reference Home and Qualifying Homes

**3.1** General. Listed specifications for the Tax Credit Reference Home cannot be altered or derated unless explicitly noted. Building attributes that affect space heating and cooling energy which are not listed in this section shall be the same for both the Tax Credit Reference Home and the Qualifying Home. Additionally, field verification is required for energy features, including the envelope insulation installation Grade[4] and the HVAC Installation Grade that affect heating and cooling energy in the Qualifying Home. Except as specified by this Section, the Tax Credit Reference Home and Qualifying Home shall be configured and analyzed using identical methods and techniques.

**3.2** Residence Specifications. The Tax Credit Reference Home and Qualifying Home shall be configured and analyzed as specified by Table 3.2(1).

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| Above-grade walls: | Type: wood frame<br>Gross area: same as Qualifying Home<br>U-Factor: from Table 3.2(2)<br>Solar absorptance = 0.75<br>Emittance = 0.90 | Same as Qualifying Home<br>Same as Qualifying Home<br><br>Same as Qualifying Home<br>Same as Qualifying Home<br>Same as Qualifying Home |
| Conditioned basement walls: | Type: same as Qualifying Home<br>Gross area: same as Qualifying Home<br>U-Factor: from Table 3.2(2) with the insulation layer on the interior side of walls | Same as Qualifying Home<br>Same as Qualifying Home<br><br>Same as Qualifying Home |

[4] ANSI/RESNET/ICC 301-2019, Section 4.2.2.2, Insulation Inspections

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| Floors over unconditioned spaces: | Type: wood frame<br>Gross area: same as Qualifying Home<br>U-Factor: from Table 3.2(2) | Same as Qualifying Home<br>Same as Qualifying Home<br><br>Same as Qualifying Home |
| Crawlspaces: | Type: vented with net free vent aperture = 1ft$^2$ per 150 ft$^2$ of crawlspace floor area.<br><br>Crawlspace walls shall be uninsulated, while the floor above the crawlspace shall be insulated according to Table 3.2(2) as a floor over unconditioned space.<br><br>U-factor: from Table 3.2(2) for floors over unconditioned spaces | Same as the Qualifying Home, but not less net free ventilation area than the Tax Credit Reference Home unless an approved ground cover in accordance with the International Residential Code Section 408.3.1 is used, in which case, the same net free ventilation area as the Qualifying Home down to a minimum net free vent area of 1ft$^2$ per 1,500 ft$^2$ of crawlspace floor area.<br>Same as Qualifying Home |
| Ceilings: | Type: wood frame<br>Gross area: same as Qualifying Home<br>U-Factor: from Table 3.2(2) | Same as Qualifying Home<br>Same as Qualifying Home<br><br>Same as Qualifying Home |

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| Roofs: | Type: composition shingle on wood sheathing | Same as Qualifying Home |
| | Gross area: same as Qualifying Home | Same as Qualifying Home |
| | Solar absorptance = 0.75 | Values from Table 3.3 shall be used to determine solar absorptance except where test data is provided for roof surface in accordance with ANSI/CRRC S100. |
| | Emittance = 0.90 | Emittance values provided by the roofing manufacturer in accordance with ANSI/CRRC S100 shall be used when available. In cases where the appropriate data are not known, same as Tax Credit Reference Home. |
| Attics: | Type: vented with aperture = 1ft$^2$ per 300 ft$^2$ ceiling area | Same as Qualifying Home |
| Foundations: | Type: same as Qualifying Home | Same as Qualifying Home |
| | Gross Area: same as Qualifying Home | Same as Qualifying Home |
| | U-Factor / R-value: from Table 3.2(2) | Same as Qualifying Home |
| Doors: | Area: 40 ft$^2$ | Same as Qualifying Home |
| | Orientation: North | Same as Qualifying Home |
| | U-factor: same as fenestration from Table 3.2(2) | Same as Qualifying Home |
| Glazing: [(a)] | Total area[(b)] = | |
| | (a) The Qualifying Home glazing area; where the Qualifying Home glazing area is less than 18% of the conditioned floor area | Same as Qualifying Home |
| | (b) 18% of the conditioned floor area; where the Qualifying Home glazing area is 18% or more of the conditioned floor area | Same as Qualifying Home |
| | Orientation: equally distributed to four (4) cardinal compass orientations (N,E,S,&W) | Same as Qualifying Home |
| | U-factor: from Table 3.2(2) | Same as Qualifying Home |

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| | SHGC: from Table 3.2(2)<br>Interior shade coefficient:<br>Summer = 0.70<br>Winter = 0.85<br>External shading: none | Same as Qualifying Home<br>Same as Tax Credit Reference Home [c]<br><br>Same as Qualifying Home |
| Skylights | None | Same as Qualifying Home |
| Thermally isolated sunrooms | None | Same as Qualifying Home |
| Air exchange rate | Specific Leakage Area (SLA)[d] = 0.00036 assuming no energy recovery, supplemented as necessary with balanced mechanical ventilation to achieve the required dwelling unit total air exchange rate (Qtot).[e], [f] | In accordance with Standard ANSI/RESNET/ICC 380, obtain airtightness test results for:<br>• Building enclosure (for detached dwelling units)<br>• Compartmentalization boundary (for attached dwelling units).<br>For attached dwelling units with airtightness test results ≤ 0.30 cfm50 per ft2 of compartmentalization boundary, the test results shall be multiplied by reduction factor Aext [g] to determine the infiltration rate. For attached dwelling units with airtightness test results > 0.30 cfm50 per ft2 of compartmentalization boundary, the test results shall be modeled as the infiltration rate.<br>For residences without dwelling unit mechanical ventilation systems, or without measured airflow, or where Aext[g] < 0.5 and the mechanical ventilation system is solely an exhaust system, the infiltration rate[h] shall be as determined above, but not less than 0.30 ACH.<br>For residences with dwelling |

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| | | unit mechanical ventilation systems, the total air exchange rate shall be the infiltration rate[(h)] as determined above, in combination[(f)] with the time-averaged dwelling unit mechanical ventilation system rate[(e),(j)] which shall be the value measured in accordance with ANSI/RESNET/ICC 380.<br>The dwelling unit mechanical ventilation system rate shall be increased as needed to ensure that the total air exchange rate is no less than Qtot = 0.03 x CFA + 7.5 x (Nbr+1) cfm. |
| Dwelling unit Mechanical ventilation system fan energy | None, except where a mechanical ventilation system is specified by the Qualifying Home, in which case:<br>Where Qualifying Home has supply-only or exhaust-only Dwelling Unit Mechanical Ventilation System: 0.35 * fanCFM * 8.76 kWh/y<br>Where Qualifying Home has balanced Dwelling Unit Mechanical Ventilation System without energy recovery or a combination of Supply and Exhaust Systems:<br>0.70 * fanCFM * 8.76 kWh/y<br>Where Qualifying Home has balanced Dwelling Unit Mechanical Ventilation System with energy recovery:<br>1.00 * fanCFM * 8.76 kWh/y<br>And where fanCFM is the minimum continuous Dwelling Unit Mechanical Ventilation System fan flow rate[g] for the Qualifying Home. | Same as Qualifying Home[(k),(l)] |

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| Internal gains: | As specified by Table 3.2(4) | Same as Tax Credit Reference Home, except as provided by ANSI/RESNET/ICC 301-2019 Section 4.2.2.5.2 . |
| Internal mass: | An internal mass for furniture and contents of 8 pounds per square foot of floor area | Same as Tax Credit Reference Home, plus any additional mass specifically designed as a Thermal Storage Element[(m)] but not integral to the building envelope or structure |
| Structural mass: | For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air | Same as Qualifying Home |
| | For masonry basement walls, same as Qualifying Home, but with insulation required by Table 3.2(2) located on the interior side of the walls | Same as Qualifying Home |
| | For other walls, for ceilings, floors, and interior walls, wood frame construction | Same as Qualifying Home |
| Heating systems [(q)] | Fuel type: same as Qualifying Home | Same as Qualifying Home [(n),(o)] |
| | Efficiencies: | |
| | Electric: air source heat pump with efficiency in accordance with Table 3.2(1)(a) | Same as Qualifying Home |
| | Non-electric furnaces: natural gas furnace with efficiency in accordance with Table 3.2(1)(a) | Same as Qualifying Home |
| | Non-electric boilers: natural gas boiler with efficiency in accordance with Table 3.2(1)(a) | Same as Qualifying Home |
| | Capacity: sized in accordance with Section 4.4.3.1, ANSI/RESNET/ICC 301-2019. | Same as Qualifying Home |
| | Installation Quality Grade[(q)] of Forced-Air HVAC System with Heat Pump: configured as Grade III in accordance with | Same as Qualifying Home[(q)] configured in accordance with ANSI/RESNET/ICC 301-2019 Addendum B- |

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| | ANSI/RESNET/ICC 301-2019 Addendum B-2020, Section 4.2.2.3.1 and modeled in accordance with ANSI/RESNET/ICC 301-2019 Addendum B-2020, Section 4.2.2.3.2. | 2020, Section 4.2.2.3.1 and modeled in accordance with ANSI/RESNET/ICC 301-2019 Addendum B-2020, Section 4.2.2.3.2. |
| Cooling systems [q] | Fuel type: Electric<br>Efficiency: in accordance with Table 3.2(1)(a)<br>Capacity: sized in accordance with Section 4.4.3.1, ANSI/RESNET/ICC 301-2019.<br>Installation Quality Grade[q] of Forced-Air HVAC System with Air Conditioner or Heat Pump: configured as Grade III in accordance with ANSI/RESNET/ICC 301-2019 Addendum B-2020, Section 4.2.2.3.1 and modeled in accordance with ANSI/RESNET/ICC 301-2019 Addendum B-2020, Section 4.2.2.3.2. | Same as Qualifying Home [n],[p]<br>Same as Qualifying Home<br>Same as Qualifying Home<br>Same as Qualifying Home[q] configured in accordance with ANSI/RESNET/ICC 301-2019 Addendum B-2020, Section 4.2.2.3.1 and modeled in accordance with ANSI/RESNET/ICC 301-2019 Addendum B-2020, Section 4.2.2.3.2. |
| Thermal distribution systems: | A thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies. | For untested air distribution systems located entirely within conditioned space volume, a cfm25 to out/CFA of 0.10 with 50% of the leakage on the return side and with the energy impacts calculated with the ducts located and insulated as in the Qualifying Home.<br>For untested air distribution systems not located entirely within conditioned space volume, a cfm25 to out/CFA of 0.15 with 50% of the leakage on the return side and with the energy impacts calculated with the ducts located and insulated as in the Qualifying Home. |

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

| Building Component | Tax Credit Reference Home | Qualifying Home |
|---|---|---|
| | | For tested air leakage, the tested duct leakage to outside tests conducted and documented by an Approved Tester in accordance with requirements of Standard ANSI/RESNET/ICC 380-2019 Section 5 with the air handler installed, and the energy impacts calculated with the ducts located and insulated as in the Qualifying Home.<br>For ductless distribution systems: DSE=1.00<br>For hydronic distribution systems: DSE=1.00 |
| Thermostat | Type: manual<br><br>Temperature setpoints: cooling temperature set point = 78 F; heating temperature set point = 68 F | Type: Same as Qualifying Home<br>Temperature setpoints: same as the Tax Credit Reference Home, except as required by ANSI/RESNET/ICC 301-2019 Section 4.4.1 if a programmable thermostat is used |

**Table 3.2(1) Notes:**

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

(b) For homes with conditioned basements and for attached homes, the Tax Credit Reference Home glazing area shall be calculated using the following equation:

$AF = A_s \times FA \times F$ where:

$AF$ = Total glazing area

$A_s$ = The smaller of the Qualifying Home glazing area OR 18% of the conditioned floor area

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

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

and where:

*Thermal boundary wall* is any wall that separates conditioned space from unconditioned space or ambient conditions, including the area of band joists or other inter-floor structure.

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

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

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

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

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

(e) The required Dwelling Unit Mechanical Ventilation System airflow rate (Qfan) shall be determined in accordance with the following equation.[5] Where this requires the Qualifying 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 Qualifying Home.

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

where:

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

and where:

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

AND

*Qinf* = 0.0521* cfm50 * wsf * (H/Hr)^0.4

OR

*Qinf* = (*NL* · wsf · CFA) / 7.3

where:

| | |
|---|---|
| *NL* | = *normalized* leakage = 1000 · (ELA / CFA) · [H / Hr]^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 ($in^2$) |
| *H* | = vertical distance between lowest and highest above-grade points within the pressure boundary (ft.) |

[5] (Informative Note) Equation taken from Addendum s to ASHRAE Standard 62.2-2016.

*Hr* = reference height = 8.202 ft.

(f) Either hourly calculations using the following equation[6] 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.

$$\boldsymbol{Q_i = Q_{fan,i} + \Phi\, Q_{inf,i}}$$

where:

$\Phi$ = 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

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

$Q_{fan,i}$ = *mechanical* Ventilation airflow rate for the time step 'i', cfm

(g) Reduction factor $A_{ext}$ (used only for attached dwelling units) shall be the ratio of exterior envelope surface area to Compartmentalization Boundary

(h) 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.

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

(j) 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 Qualifying Home.

i. 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.

ii. Where the dwelling unit mechanical ventilation system is a supply system or an exhaust system, and not a balanced system nor a combination of systems, the ventilation rate shall be the value measured in the Qualifying Home or adjusted in accordance with the previous step.

iii. Where the dwelling unit mechanical ventilation system is a balanced system or a combination of systems, the system airflows shall be analyzed separately in accordance with the previous steps. For software that does not explicitly model multiple, separate supply and exhaust systems, the dwelling unit mechanical ventilation system shall be modeled as a balanced system where the ventilation rate of the Qualifying Home is the sum of either the exhaust airflows measured in the dwelling unit or the sum of the supply airflows measured in the unit, whichever is

[6] (Informative Note) Equation taken from ASHRAE Standard 62.2-2016, Normative Appendix C, equations (C7) and (C8).

greater.

(k) Dwelling unit mechanical ventilation system fan watts shall be the value observed in the Qualifying Home for the highest airflow setting. Where not available, fan watts shall be based on Table 3.2(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 (e) of Table 3.2(1). For CFIS systems, the cfm used to determine fan watts shall be the larger of 400 cfm per 12 kBtu/h cooling capacity or 240 cfm per 12 kBtu/h heating capacity.

Table 3.2(1a) Default Ventilation System Fan Power for Qualifying 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 |

(l) Where the ventilation system is designed to serve the ventilation needs of more than one dwelling unit, the Qualifying Home kWh/y fan energy shall be calculated as a proportion of the entire system fan energy, using the system airflow, ventilation type, fan run time and the rated fan power of the shared system. The Qualifying Home ventilation fan energy shall be calculated as the fan power of the entire system multiplied by the ratio of dwelling unit airflow to the system airflow. Where the system fan power cannot be determined, 1 Watt/cfm shall be used. Where the dwelling unit airflow cannot be measured, the Qualifying Home shall use Qfan, as determined in accordance with Note (e) of Table 3.2(1) when calculating fan energy

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

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

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

*Table 3.2(1)(a) Standard Tax Credit Reference Home Heating and Cooling Equipment Efficiencies [(k),(l),(m),(n)]*

| Qualifying Home Fuel | Function | Tax Credit 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 |

(o) For a Qualifying Home without a proposed heating system, a heating system with the efficiency specified in Table 3.2(1)(a) shall be assumed for both the Tax Credit Reference Home and Qualifying Home. For electric heating systems, an air-source heat pump with efficiency in accordance with Table 3.2(1)(a) shall be selected.

(p) For a Qualifying Home without a proposed cooling system, an electric air conditioner with efficiency specified in Table 3.2(1)(a) shall be assumed for both the Tax Credit Reference Home and the Qualifying Home.

(q) The grading of the installation of HVAC system shall be determined and documented by a Certified Rater using the onsite inspection protocol specified by ANSI/RESNET/ACCA Standard 310.

*Table 3.2(2) Component Heat Transfer Characteristics for Tax Credit Reference Home [(a)]*

| Climate Zone [(b)] | Fenestration and Opaque Door U-Factor | Glazed Fenestration Assembly SHGC | Ceiling U-Factor | Frame Wall U-Factor | Floor Over Unconditioned Space U-Factor | Basement Wall Insulation R-Value[(c)] | Slab-on-Grade [(d, e)] Insulation R-Value & Depth |
|---|---|---|---|---|---|---|---|
| 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 3.2(2) Notes:

(a) Non-fenestration U-Factors shall be obtained from measurement, calculation, or an approved source.
(b) Climates zones shall be as specified by the International Energy Conservation Code.
(c) For basements that are within the conditioned space volume, basement walls shall be modeled as having continuous exterior wall insulation.
(d) R-5 shall be added to the required R-value for slabs with embedded heating.
(e) Insulation shall extend downward from the top of the slab vertically to the depth indicated.

*Table 3.2(4). Internal Gains for Tax Credit Reference Home [a]*

| End Use / Component | Sensible Gains (Btu/day) | | | Latent Gains (Btu/day) | | |
|---|---|---|---|---|---|---|
| | a | b | c | a | b | c |
| Residual MELs | | 7.27 | | | 0.38 | |
| Interior lighting | 4,253 | 7.48 | | | | |
| Refrigerator | 5,955 | | 168 | | | |
| TVs | 3,861 | | 645 | | | |
| Range/Oven (elec) [b] | 2,228 | | 262 | 248 | | 29 |
| Range/Oven (gas) [b] | 4,086 | | 488 | 1,037 | | 124 |
| Clothes Dryer (elec) [b] | 502 | | 143 | 56 | | 16 |
| Clothes Dryer (gas) [b] | 562 | | 159 | 69 | | 19 |
| Dish Washer | 168 | | 67 | 168 | | 67 |
| Clothes Washer | 135 | | 38 | 15 | | 4 |
| Gen water use | -1227 | | -409 | 1,245 | | 415 |
| Occupants [c] | | | 3716 | | | 2,884 |

**Notes for Table 3.2(4)**

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

(b) For Qualifying Homes with electric appliance use (elec) values and for Qualifying 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 the occupants are present in the home for 16.5 hours per day.

*Table 3.3 Default Solar Absorptance for Various Roofing Surfaces[7]*

| Roof Materials | Absorptance | Roof Materials | Absorptance |
|---|---|---|---|
| Composition Shingles | | Wood Shingles | |
| Dark | 0.92 | Dark | 0.90 |
| Medium | 0.85 | Medium | 0.80 |
| Light | 0.75 | | |
| | | Concrete/Cement | |
| Tile/Slate | | Dark | 0.90 |
| Dark | 0.90 | Medium | 0.75 |
| Medium | 0.75 | Light | 0.60 |
| Terra cotta | 0.65 | White | 0.30 |
| Light | 0.60 | | |
| White | 0.30 | Membrane | |
| | | Dark | 0.90 |
| Metal | | Medium | 0.75 |
| Dark | 0.90 | Light | 0.60 |

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

| Roof Materials | Absorptance | Roof Materials | Absorptance |
|---|---|---|---|
| Medium | 0.75 | White | 0.30 |
| Galvanized, unfinished | 0.70 | | |
| Light | 0.60 | Built-Up (gravel surface) | |
| Galvalum, unfinished | 0.35 | Dark | 0.92 |
| White | 0.30 | Medium | 0.85 |
| | | Light | 0.75 |

# Appendix B

Acceptance Criteria for Building Loads Tests

**ANSI/ASHRAE Standard 140, Class II, Tier 1 Tests.** The ANSI/ASHRAE Standard 140-, Class II, Tier 1 test procedure is a requirement for all software tools to be accredited. The acceptance criteria in million Btu (MBtu) for this test suite are developed in accordance with Appendix 22 of ANSI/ASHRAE Standard 140 and are as follows:

**Annual Heating Loads**
**Colorado Springs, CO**

| Case | range max | range min |
|---|---|---|
| L100AC | 79.48 | 48.35 |
| L110AC | 103.99 | 71.88 |
| L120AC | 64.30 | 35.98 |
| L130AC | 53.98 | 39.75 |
| L140AC | 56.48 | 43.24 |
| L150AC | 71.33 | 39.76 |
| L155AC | 74.18 | 42.66 |
| L160AC | 81.00 | 48.78 |
| L170AC | 92.40 | 58.11 |
| L200AC | 185.87 | 106.41 |
| L202AC | 190.05 | 111.32 |
| L302XC | 90.52 | 19.20 |
| L304XC | 75.32 | 23.51 |
| L322XC | 118.20 | 18.71 |
| L324XC | 80.04 | 32.71 |

**Annual Heating Load Deltas**
**Colorado Springs, CO**

| Case | range max | range min |
|---|---|---|
| L110AC-L100AC | 29.68 | 17.43 |
| L120AC-L100AC | -7.67 | -18.57 |
| L130AC-L100AC | -5.88 | -27.50 |
| L140AC-L100AC | 0.37 | -24.42 |
| L150AC-L100AC | -3.02 | -12.53 |
| L155AC-L150AC | 6.88 | -1.54 |
| L160AC-L100AC | 5.10 | -3.72 |
| L170AC-L100AC | 17.64 | 7.12 |
| L200AC-L100AC | 107.66 | 56.39 |
| L202AC-L200AC | 11.25 | -0.51 |
| L302XC-L100AC | 14.50 | -31.43 |
| L302XC-L304XC | 17.75 | -4.46 |
| L322XC-L100AC | 39.29 | -33.54 |
| L322XC-L324XC | 38.27 | -14.17 |

**Annual Cooling Loads**
**Las Vegas, NV**

| Case | range max | range min |
|---|---|---|
| L100AL | 64.88 | 41.47 |
| L110AL | 68.50 | 46.80 |
| L120AL | 60.14 | 40.08 |
| L130AL | 45.26 | 30.98 |
| L140AL | 30.54 | 19.52 |
| L150AL | 82.33 | 49.46 |
| L155AL | 63.06 | 35.58 |
| L160AL | 72.99 | 51.26 |
| L170AL | 53.31 | 34.05 |
| L200AL | 83.43 | 56.18 |
| L202AL | 75.96 | 49.50 |

**Annual Cooling Load Deltas**
**Las Vegas, NV**

| Case | range max | range min |
|---|---|---|
| L110AL-L100AL | 7.84 | -0.98 |
| L120AL-L100AL | 0.68 | -8.67 |
| L130AL-L100AL | -9.69 | -24.40 |
| L140AL-L100AL | -20.29 | -38.68 |
| L150AL-L100AL | 20.55 | 7.50 |
| L155AL-L150AL | -9.64 | -22.29 |
| L160AL-L100AL | 12.78 | 3.88 |
| L170AL-L100AL | -4.83 | -15.74 |
| L200AL-L100AL | 21.39 | 6.63 |
| L200AL-L202AL | 14.86 | 2.03 |

# Appendix C

## Tax Credit Reference Home Auto-Generation Test Suite for Verification of Software Tools Used for Tax Credit Qualification

### *Introduction*

This report contains requirements regarding the Tax Credit Reference Home auto-generation test suite for tax credit qualification. The Tax Credit Reference Home auto-generation test suite is one of four minimum test suites that this publication requires for software tools used for tax credit qualification. The test cases in this test suite are designed to verify that software tools automatically generate accurate Tax Credit Reference Homes given only the building information for the Qualifying Home.

### *Reporting*

Software tools applying for accreditation shall provide evidence that their software meets the requirements of this test suite. The software tool provider or software vendor is responsible for producing the documentation needed to show that the software has been verified through this test suite. The software tool provider or software vendor shall also provide sufficient test files and reporting functionality to allow a third-party user of the software to independently verify the attributes of the Tax Credit Reference Home. In some cases, the data needed to verify accuracy is of no interest or value to the typical end-user of the software, but in any case, the software tool shall generate it and make it accessible to a third-party reviewer.

### *Minimum Requirements*

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

1. Areas and overall U-factors (or R-values in the case of slab-on-grade construction) for all building components, including ceilings, walls, floors, windows (by orientation) and doors.
2. Overall solar-heat gain coefficient ($SHGC_o$)[8] of the windows during heating.
3. Overall solar-heat gain coefficient ($SHGC_o$) of the windows during cooling.
4. Wall solar absorptance and infrared emittance
5. Roof solar absorptance and infrared emittance
6. Total internal gains to the home (Btu/day)

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

7. Specific leakage area (SLA) for the building, by zone or as $SLA_o$[9], as appropriate
8. HVAC installation quality Grades in accordance with ANSI/RESNET/ACCA 380
9. Attic net free ventilation area ($ft^2$)
10. Crawlspace net free ventilation area ($ft^2$), if appropriate
11. Exposed masonry floor area and carpet and pad R-value, if appropriate
12. Heating system labeled ratings, including AFUE, COP, or HSPF, as appropriate.
13. Cooling system labeled ratings, including SEER or EER, as appropriate.
14. Thermostat schedule for heating and cooling
15. Air Distribution System Efficiency (DSE).

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

### *Auto-generation Test Suite*

Test Case1. ASHRAE Standard 140 case L100 building configured on a raised floor over outdoor air, located in Baltimore, MD, including a total of 3 bedrooms and the following mechanical equipment: gas furnace with AFUE = 82% and central air conditioning with SEER = 11.0; a gas range, oven and clothes dryer; all other appliances are electric.

Test Case 2. ASHRAE Standard140 case L100 configured on an un-vented crawlspace with R-7 crawlspace wall insulation, located in Dallas, TX, including a total of 3 bedrooms and the following mechanical equipment: electric heat pump with HSPF = 7.5 and SEER = 12.0; all appliances are electric.

Test Case 3. ASHRAE Standard 140 case L304 in Miami, configured as specified in the HERS BESTEST procedures, located in Miami, FL, including a total of 2 bedrooms and the following mechanical equipment: electric strip heating with COP = 1.0 and central air conditioner with SEER = 15.0; all appliances are electric.

Test Case 4. ASHRAE Standard 140 case L324 configured as specified as in the ASHRAE Standard 140 procedures, located in Colorado Springs, CO, including a total of 4 bedrooms and the following mechanical equipment: gas furnace with AFUE = 95% and no air conditioning; a gas range, oven and clothes dryer; all other appliances are electric.

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

### *Verification Criteria*

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

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

*Table 1. Verification Criteria for Test Cases 1 – 4*

| **Tax Credit Reference Home Building Component** | **Test 1** | **Test 2** | **Test 3** | **Test 4** |
|---|---|---|---|---|
| Above-grade walls ($U_o$) | 0.082 | 0.082 | 0.082 | 0.060 |
| Above-grade wall solar absorptance (α) | 0.75 | 0.75 | 0.75 | 0.75 |
| Above-grade wall infrared emittance (ε) | 0.90 | 0.90 | 0.90 | 0.90 |
| Basement walls ($U_o$) | n/a | n/a | n/a | 0.059 |
| Above-grade floors ($U_o$) | 0.047 | 0.047 | n/a | n/a |
| Slab insulation R-Value | n/a | n/a | 0 | 0 |
| Ceilings ($U_o$) | 0.030 | 0.035 | 0.035 | 0.030 |
| Roof solar absorptance (α) | 0.75 | 0.75 | 0.75 | 0.75 |
| Roof infrared emittance (ε) | 0.90 | 0.90 | 0.90 | 0.90 |
| Attic vent area* ($ft^2$) | 5.13 | 5.13 | 5.13 | 5.13 |
| Crawlspace vent area* ($ft^2$) | n/a | 10.26 | n/a | n/a |
| Exposed masonry floor area * ($ft^2$) | n/a | n/a | 307.8 | 307.8 |
| Carpet & pad R-Value | n/a | n/a | 2.0 | 2.0 |
| Door Area ($ft^2$) | 40 | 40 | 40 | 40 |
| Door U-Factor | 0.40 | 0.65 | 1.20 | 0.35 |
| North window area* ($ft^2$) | 67.50 | 67.50 | 67.50 | 50.02 |
| South window area* ($ft^2$) | 67.50 | 67.50 | 67.50 | 50.02 |
| East window area* ($ft^2$) | 67.50 | 67.50 | 67.50 | 50.02 |
| West window area* ($ft^2$) | 67.50 | 67.50 | 67.50 | 50.02 |
| Window U-Factor | 0.40 | 0.65 | 1.20 | 0.35 |
| Window $SHGC_o$ (heating) | 0.34 | 0.34 | 0.34 | 0.34 |
| Window $SHGC_o$ (cooling) | 0.28 | 0.28 | 0.28 | 0.28 |
| $SLA_o$* ($ft^2/ft^2$) | 0.00036 | 0.00036 | 0.00036 | 0.00036 |
| Sensible Internal gains* (Btu/day) | 55,470 | 52,794 | 48,111 | 83,103 |
| Latent Internal gains* (Btu/day) | 13,807 | 12,698 | 9,259 | 17,934 |
| Heating system rating and efficiency | AFUE = 78% | HSPF = 7.7 | HSPF = 7.7 | AFUE = 78% |
| Cooling system rating and efficiency | SEER = 13.0 | SEER = 13.0 | SEER = 13.0 | SEER = 13.0 |
| HVAC System Installation Grade | III | III | III | III |
| Air Distribution System Efficiency | 0.80 | 0.80 | 0.80 | 0.80 |
| Thermostat Type | Manual | Manual | Manual | Manual |
| Heating thermostat settings | 68 F (all hours) | 68 F (all hours) | 68 F (all hours) | 68 F (all hours) |
| Cooling thermostat settings | 78 F (all hours) | 78 F (all hours) | 78 F (all hours) | 78 F (all hours) |

e-Ratio Tests. The e-Ratio tests require that the Tax Credit Reference Homes for test cases 1-3 be stored or recreated in the software tool as Qualifying Home B and simulated as any other Qualifying Home would be simulated. Test case 4 is not subjected to this e-Ratio test sequence. If the resulting Qualifying Home B is correctly configured to be identical to its appropriate Tax Credit Reference Home A, energy use calculations arising from normal operation of the software tool should produce virtually identical energy use for both Qualifying Home B and Tax Credit Reference Home B for this round of tests.

The e-Ratio shall be calculated from the simulation results as follows:

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

Verification criteria for these calculations shall be ± 0.5% of 1.00. Thus, for each of the preceding test cases (1-3), the e-Ratio resulting from these software tool simulations and the subsequent e-Ratio calculations shall be greater than or equal to 0.995 **and** less than or equal to 1.005. The software shall provide functionality that allows a third-party reviewer to have access to the files necessary to independently verify the e-Ratio calculation.

# Appendix D

## RESNET HVAC Test Suites 1 & 2

*Required Capabilities*

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

**System Types**

System types that shall be supported by all tools:

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

Optional system types that may be supported include:

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

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

| HVAC Equipment Type | Heating Efficiency Metric | Cooling Efficiency Metric | Comments: |
|---|---|---|---|
| Gas or Fuel Furnaces | AFUE | | Includes wall furnaces, floor furnaces and central forced air furnaces. |

| | | | |
|---|---|---|---|
| Electric Resistance Furnace | COP | | Use COP of 1.0, an HSPF of 3.413 may be equivalent and acceptable for some tools. |
| Air Source Heat Pump <65 kBtu/h | HSPF | SEER | |
| Air Cooled Central Air Conditioner <65 kBtu/h | | SEER | |
| **Air Cooled Window Air Conditioner** | | **EER** | PTAC units are included in this category |

### *Detailed Default Inputs*

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

*Default Values for use with Detailed HVAC Simulation Tools*

| DOE-2 Keyword: | Description (units) | Value |
|---|---|---|
| **HEATING-EIR** | Heat Pump Energy Input Ratio compressor only, (1/cop) | 0.582*(1/(HSPF/3.413)) |
| COOLING-EIR | Air Conditioner Energy Input Ratio compressor only, (1/cop) | 0.941*(1/(SEER/3.413)) |
| DEFROST-TYPE | Defrost method for outdoor unit, (Reverse cycle) | REVERSE-CYCLE |
| DEFROST-CTRL | Defrost control method, (Timed) | TIMED |
| DEFROST-T (F) | Temperature below which defrost controls are activated, (°F) | 40° |
| CRANKCASE-HEAT | Refrigerant crankcase heater power, (kW) | 0.05 |
| CRANK-MAX-T | Temperature above which crankcase heat is deactivated, (°F) | 50° |
| MIN-HP-T (F) | Minimum temperature at which compressor operates, (°F) | 0° |
| MAX-HP-SUPP-T | Temperature above which auxiliary strip heat is not available, (°F) | 50° |
| MAX-SUPPLY-T (heating, heat pump) | Maximum heat pump leaving air temperature from heating coil, (°F) | 105° |
| MAX-SUPPLY-T (heating, natural gas | Maximum gas furnace leaving air temperature from heating | 120° |

| DOE-2 Keyword: | Description (units) | Value |
|---|---|---|
| furnace) | coil, (°F) | |
| FURNACE-AUX | Natural gas furnace pilot light energy consumption, (Btu/h) | 100 |
| MIN-SUPPLY-T (cooling) | Minimum cooling leaving air temperature from cooling coil, (°F) | 55° |
| SUPPLY-KW | Indoor unit standard blower fan power, (kW/cfm) | 0.0005 |
| SUPPLY-DELTA-T | Air temperature rise due to fan heat, standard fan, (°F) | 1.580° |
| SUPPLY-KW | Indoor unit standard blower fan power, high efficiency fan, (kW/cfm) | 0.000375 |
| SUPPLY-DELTA-T | Air temperature rise associated due to fan heat, high efficiency fan, (°F) | 1.185° |
| COIL-BF | Coil bypass factor, (dimensionless) | 0.241 |
| **Other parameters:** | | |
| Part load performance curves | Compressor part load performance curves | Henderson, et.al.[10] |
| Heating system size | Installed heat pump size, (kBtu/h) | Determined by Manual J (specified) |
| Coil airflow | Indoor unit air flow, (cfm) | 30 cfm/(kBtu/h) |
| Cooling system size | Installed air conditioner size, (kBtu/h) | Determined by Manual J (specified) |

### *List of Tests*

The following test suites represent tests that tools shall pass to be accredited. All tests are to be performed using the L100 building case described by the ASHRAE Standard 140 procedures.[10] All tests are to be performed assuming Grade I heating and cooling system installations.

For each test case, acceptance criteria are provided. In order to pass a specific test, tools shall predict percentage energy use changes for the specified heating and/or cooling system tests that falls between the upper and lower acceptance criteria for that test.

Tools that do not model the performance of HVAC equipment in detail shall provide for climate adjusted equipment performance factors in order to fall

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

within the acceptance criteria for these tests. Methods of adjusting the manufacturer's nameplate ratings to account for climate dependent performance have been reported.[11]

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

*Air Conditioning System Test Specifications*

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

**Interim Air Conditioning System Acceptance Criteria**

| Test # | Mfg. Equip Performance Rating (MEPR) Change | Low Acceptance Criteria | High Acceptance Criteria |
|---|---|---|---|
| HVAC1a | Base case | --- | --- |
| HVAC1b | -23.1% | -23.58% | -17.38% |

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

*Gas Heating System Test Specifications*

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

**Interim Gas Heating System Acceptance Criteria**

| Test # | Mfg. Equip Performance Rating (MEPR) Change | Low Acceptance Criteria | High Acceptance Criteria |
|---|---|---|---|
| HVAC2a | Base case | --- | --- |
| HVAC2b | -13.3% | -13.3% | -11.57% |

[11] Fairey, P., D.S. Parker, B. Wilcox and M. Lombardi, "Climate Impacts on Heating Seasonal Performance Factor (HSPF) and Seasonal Energy Efficiency Ratio (SEER) for Air Source Heat Pumps." ASHRAE Transactions, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA, June 2004. (Also available online at http://www.fsec.ucf.edu/bldg/pubs/hspf/)

**Electric Heating System Test Specifications**

| Test # | System Type | Capacity | Location | Efficiency |
|---|---|---|---|---|
| HVAC2c | Air Source Heat Pump | 56.1 kBtu/h | Colorado Springs, CO | HSPF = 6.8 |
| HVAC2d | Air Source Heat Pump | 56.1 kBtu/h | Colorado Springs, CO | HSPF = 9.85 |
| HVAC2e | Electric Furnace | 56.1 kBtu/h | Colorado Springs, CO | COP =1.0 |

**Interim Electric Heating System Acceptance Criteria**

| Test # | Mfg. Equip Performance Rating (MEPR) Change | Low Acceptance Criteria | High Acceptance Criteria |
|---|---|---|---|
| HVAC2c | Base case | --- | --- |
| HVAC2d | -22.9% | -44.31% | -14.36% |
| HVAC2e | 99.3% | 41.81% | 113.11% |

# Appendix E

## RESNET Distribution System Efficiency (DSE) Test Suite

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

*Test Case Specification*

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

Furnace and air conditioner heating and cooling capacities should be modified for each of the duct system efficiency test cases according to the values provided in Tables 1a and 2a. Similarly, the specified heating and cooling coil airflow (cfm) should be altered by case using a value of 360 cfm/ton (30 cfm/kBtu) of capacity. Also, the exterior air film resistance of the duct system should be added to the specified duct R-values given in Tables 1a and 2a to obtain agreement for duct conductance. For non-insulated sheet metal ducts (R-0) the air film has a resistance of approximately R=1.5 $ft^2$-$^oF$-hr/Btu and for insulated ducts (R=6) the air film has a resistance of R=1.0 as shown by test results obtained by Lauvray (1978) at a typical residential duct airflow rate of 530 fpm.[12] These values are currently established for the purposes of duct design calculations by ASHRAE within the Handbook of Fundamentals (2001, p. 34.15). Thus, unless the software undergoing test accounts for these film resistances, the uninsulated sheet metal duct (R=0 in Tables 1a and 2a) should be entered as R=1.5 while the insulated ducts (R=6 in tables) should be entered as R=7.

For the heating comparison test cases (Table 1a), which assume a basement, use the ASHRAE Standard 140 Case L322 home. The basement is to be unconditioned, have a floor area equal to the main floor area (1539 $ft^2$) and have R11 insulation in the floor joists of the main floor with a framing fraction

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

of 13%. The basement case has no basement wall insulation. For the cooling comparison test cases (Table 2a), use the ASHRAE Standard 140 case L100 home.

### *Bounds Criteria*

The bounds criteria for these tests were established using ASHRAE Standard 152, using the spreadsheet tool constructed for the U.S. DOE *Building America* program by Lawrence Berkeley National Laboratory (LBNL).[13] In all cases, the input values for the Standard 152 calculations assumed the following:

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

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

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

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

### *Heating Energy Tests*

**Table 1a. Heating Energy DSE Comparison Test Specifications**

| Test # | Location | System Type | System Capacity (kBtu/h) | Duct Location | Duct Leakage | Duct R-val* |
|---|---|---|---|---|---|---|
| HVAC3a (base case) | Colorado Springs, CO | Gas Furnace | 46.6 | 100% conditioned | None | R=0 |
| HVAC3b | Colorado Springs, CO | Gas Furnace | 56.0 | 100% in basement | None | R=0 |
| HVAC3c | Colorado Springs, CO | Gas Furnace | 49.0 | 100% in basement | None | R=6 |
| HVAC3d | Colorado Springs, CO | Gas Furnace | 61.0 | 100% in basement | 250 $cfm_{25}$ | R=6 |

* Duct R-value does not include air film resistances. For uninsulated ducts, this film resistance is approximately R=1.5 and for insulated ducts it is approximately R=1.0. If software does not consider this

[13] See https://www.energy.gov/eere/buildings/downloads/ashrae-standard-152-spreadsheet

air film resistance in detail, then these air film resistances should be added.

| Table 1b. Heating Energy DSE Comparison Test Bounds Criteria | | | |
|---|---|---|---|
| Test # | Target Delta* Heating Energy Relative to HVAC3a | Minimum Delta* Heating Energy | Maximum Delta* Heating Energy |
| HVAC3a | Base case | --- | --- |
| HVAC3b | 26.4% | 5.06% | 31.4% |
| HVAC3c | 7.5% | 1.93% | 12.5% |
| HVAC3d | 20% | 4.49% | 25% |
| * Delta = % Change in energy use = ((alternative – base case) / (base case)) * 100 | | | |

**Cooling Energy Tests**

| Table 2a. Cooling Energy DSE Comparison Test Specifications | | | | | | |
|---|---|---|---|---|---|---|
| Test # | Location | System Type | System Capacity (kBtu/h) | Duct Location | Duct Leakage | Duct R-val* |
| HVAC3e (base case) | Las Vegas, NV | Air Conditioner | -38.4 | 100% conditioned | None | R=0 |
| HVAC3f | Las Vegas, NV | Air Conditioner | -49.9 | 100% in attic | None | R=0 |
| HVAC3g | Las Vegas, NV | Air Conditioner | -42.2 | 100% in attic | None | R=6 |
| HVAC3h | Las Vegas, NV | Air Conditioner | -55.0 | 100% in attic | 250 $cfm_{25}$ | R=6 |
| * Duct R-value does not include air film resistance. For uninsulated ducts, this film resistance is approximately R=1.5 and for insulated ducts it is approximately R=1.0. If software does not consider this air film resistance in detail, then these air film resistances should be added. | | | | | | |

| Table 2b. Cooling Energy DSE Comparison Test Bounds Criteria | | | |
|---|---|---|---|
| Test # | Target Delta* Cooling Energy Relative to HVAC3e | Minimum Delta* Cooling Energy | Maximum Delta* Cooling Energy |
| HVAC3e | Base case | --- | --- |
| HVAC3f | 31.2% | 19.54% | 36.2% |
| HVAC3g | 11.5% | 6.28% | 16.5% |
| HVAC3h | 26.1% | 14.76% | 31.1% |
| * Delta = % Change in energy use = ((alternative – base case) / (base case)) * 100 | | | |

# Attachment D

# Draft
# Charter of the RESNET Software Consistency Committee

**Amended by the RESNET Board of Directors on July XX, 2020**

**Background of Software Consistency Committee (SCC)**

The SCC was formed as part of a mechanism by which RESNET can improve consistency of HERS Index scores and modeled energy consumption (based on the RESNET/ICC ANSI Standard 301) among RESNET accredited HERS Rating Software Tools and enhance accreditation testing parameters. This is intended to be a continuous, ongoing process aimed at improving consistency.
This process will only address HERS ratings moving forward, it will not address ratings that have already been completed. This process is not meant to provide an immediate resolution for a specific rating, but to improve consistency problems over time.

**Responsibilities of the SCC**

The purpose of the SCC will be to hear, evaluate, and respond to software modeling consistency inquires put forth by RESNET members. The SCC will also have the ability to proactively promote consistency through group discussion, creation of RESNET Modeling Guidelines, recommended updates to Publication 002 and requests for Standards interpretations.

The SCC will be comprised of one member from every RESNET accredited software vendor, along with the RESNET Energy Modeling Director (EMD) and other industry experts that are able to contribute. Other RESNET members may apply to join as non-voting members of the SCC. The SCC will vote on recommending approval of any new members. Only the EMD, software vendor representatives, and RESNET Board approved energy modeling subject matter experts shall be voting members. Additional members of RESNET accredited software vendors can join the SCC as non-voting members.

RESNET will hire a technical consultant with extensive knowledge of building energy software modeling, who will serve as the RESNET Energy Modeling Director (EMD). The EMD will be recommended by RESNET staff and, approved by the RESNET Board. The person will serve as the Chairman of the SCC.
The EMD shall be authorized to make proposals to the RESNET Standards Development Committee 300 on needed changes to RESNET Publication No. 002 “Procedures for Verification of RESNET Accredited HERS Software Tools”. Such proposals will be subject to full committee consideration only if requested by any SCC

member, in which case voting members of the SCC shall vote to approve the proposed change by majority rule.

**SCC Modeling Consistency Inquiry Process**

Any RESNET accredited HERS Rating Software Provider, certified RESNET HERS Rater or RESNET member may submit a “Modeling Consistency Inquiry” to the Chairman of the SCC (EMD). The inquiry must consist of the following content:

- A description of inconsistent modeling results between two or more software tools with as equivalent as possible input parameters, including the results from all of the software tools.
- Approval from one or more of the involved software vendors agreeing that the inputs are correct for that vendor’s software.
- Access to a set of inputs in all relevant software that will allow the SCC to reproduce the inconsistency. The RESNET EMD shall have access to all accredited software tools.
- Any additional research, notes, or suggestions relevant to the inquiry.

Once an inquiry has been submitted, the SCC will proceed with a resolution process.

**SCC Modeling Consistency Inquiry Resolution Process**

1) Inquiry is filed by interested party.
    a) The RESNET EMD must first verify that software inputs are equivalent between subject software tools. The SCC may also develop other filtering criteria that an inquiry must meet.
    b) The inquiry must be accepted by the RESNET EMD. The EMD shall assess magnitude of the inconsistency and the effort required to solve the issue. The EMD will then decide whether to address the inquiry immediately, dismiss the inquiry, or add the inquiry to a prioritized backlog.
2) Inquiry is distributed to software vendors involved in the inquiry.
3) The EMD will analyze the inconsistency and attempt to determine the root cause. The EMD Chair will rely on assistance from software vendors to access diagnostics and help determine root cause of inconsistency. At this point, the EMD can dismiss the inquiry if it does not meet the filtering criteria.
4) The EMD shall then distribute a summary of the inconsistency to all SCC members (excluding information that was provided to the EMD by software vendors and marked as proprietary), soliciting suggestions on how to resolve the inconsistency. If necessary, the EMD will schedule a SCC meeting and set an agenda to discuss. Meeting can cover several inquiries if necessary and appropriate.
5) The EMD shall draft a Consistency Resolution Proposal (CRP), including resolution timeline (see description below). The CRP shall be based on meeting discussions as well as follow up analysis by the EMD and committee members.

6) The CRP shall be developed by the EMD with input from the members of the SCC and presented to SCC within 30 business days of original inquiry receipt.
7) The CRP will be subject to a committee vote only if requested by any SCC member, in which case voting members of the SCC will vote to approve the CRP. A simple majority rules. If not approved, CRP must undergo revision until approved. The first vote shall be executed within 10 business days after final CRP is presented to SCC.
    a) Grievances: Any RESNET accredited software vendor, or the submitter of a consistency inquiry, may appeal any decision of the RESNET EMD. These appeals shall go directly to the RESNET Board. The RESNET Board will review a written description of the appeal and vote to either uphold the EMD's decision or give guidance to the EMD and request a revised decision.
8) The SCC will deliver the CRP to the original inquirer, as well as to RESNET staff, and RESNET staff shall execute required action items.
9) (If necessary) Software tools will follow compliance requirements within the timeframes specified by the CRP.

**SCC Consistency Resolution Proposal (RP)**

A consistency resolution proposal must be one of 5 determinations. The RESNET EMD will have flexibility to adjust timing of resolution action-items to allow bundling several changes into one update cycle if appropriate.

**Option 1: Interpretation**
It is deemed that there is a difference in how software tools are interpreting a RESNET Standard or Policy, an interpretation shall be requested. Software tools must comply with the interpretation in their first released version after the interpretation is issued. If appropriate, test coverage may be added to RESNET Publication 002.

**Option 2: Infraction**
It is deemed that one or more software tools are not in compliance with RESNET Standards or Policies, the tools must achieve compliance. Infraction will be reported to RESNET staff as an official complaint.

**Option 3: Prescribed Modeling Methodology**
It is deemed that all software tools are in compliance with RESNET Standards, but have chosen different methodologies or assumptions in their energy modeling engine. The EMD may determine that the best resolution will be a prescribed modeling method mandated by RESNET. This can involve either an amendment proposal to ANSI 301, or a RESNET policy creation/update to prescribe certain required modeling techniques.

**Option 4: Modeling Guideline & Test Criteria Change**

It is deemed that all software tools are in compliance with RESNET Standards, but have chosen different methodologies or assumptions in their energy modeling engine. With this type of proposal, the SCC must also issue a modeling procedure to be added to a RESNET Modeling Guidelines (new RESNET document), which is recommended to be followed by all RESNET accredited software tools (but not required). Modeling Guidelines must be consistent with RESNET/ICC ANSI Standard 301. RESNET Publication 002 shall be updated with tighter test coverage based on the new modeling guidelines, thereby enforcing consistency. The EMD shall propose how much time software vendors will have to pass new tests. Implementation timing may vary significantly depending on complexity of the issue.

**Option 5: Dismissal**
Inconsistency is deemed insignificant, acceptable, or unsolvable within a reasonable effort, and no action is required. If deemed significant but unsolvable, this will be recorded and a description of the inconsistency will be posted by RESNET, accessible by all members. SCC should strive to avoid this resolution whenever possible.

**Confidentiality of Materials**

All documentation submitted to the members of the SCC, the RESNET Energy Modeling Director and RESNET staff shall be handled in strict confidence and not distributed without the express written approval of the party that provided the material. without the express written approval of the party that provided the material by the party.