RESNET
Residential Energy Services Network
Setting the STANDARD for QUALITY

Minutes
RESNET Board of Directors Annual Board Meeting
February 20, 2007
Executive Conference Room 4
Sheraton San Diego Hotel & Marina
San Diego, California

Members Attending
Ben Adams
Steve Byers
Eric Borsting
Richard Faesy
Philip Fairey
Ken Fonorow
David Goldstein
Tom Hamilton
Bruce Harley
Michael Holtz
Mark Jansen
Galo LeBron
C.T. Loyd
Greg Nahn
Lee O'Neal
Kelly Parker
Douglas Walter
Daran Wastchak
David Wilson
Barb Yankie

Members Absent
Joseph Lstiburek

Staff Attending
Steve Baden
Claudia Brovick
Kathy Spigarelli

Call to Order

Residential Energy Services Network (RESNET) Board President Kelly Parker called the meeting to order at 8:46 a.m. Pacific. There was a quorum of members present. The members were notified by e-mail on November 24, 2006.

Approval of the Agenda

Bruce Harley moved that the proposed agenda be approved. Michael Holtz seconded the motion. The motion passed.

Approval of Minutes

Richard Faesy moved that the minutes of the December 20, 2006 Board meeting minutes be approved, with the modification that Greg Nahn was not in attendance. Daran Wastchak seconded the motion. The motion passed. Michael Holtz abstained.

Report on RESNET / Building Performance Institute (BPI) Discussions

Steve Baden reported to the Board of the discussions that have been taken place between representatives of the RESNET and BPI Boards of Directors. The RESNET representatives are RESNET Board president Kelly Parker, vice president David Goldstein, and immediate past president Philip Fairey.

There was a meeting of the representatives in New York on January 17, 2007. The group adopted the following statement:

"In order to take advantage of the emerging opportunities to improve the performance of buildings, representatives of the BPI & RESNET Boards of Directors have met and agreed to investigate developing a seamless relationship between the organizations to create a robust national market and infrastructure for certified building performance."

The RESNET and BPI board representatives also agreed to the goal of harmonizing the two standards and investigate coalescing the two body's organizational structure.

The RESNET Board directed RESNET staff and board representatives to continue the discussions with BPI board representatives.

Financial Report

Lee O'Neal made a motion to receive the RESNET 2006 Financial Report submitted by RESNET's accounting firm Davis & Dash. Ben Adams seconded the motion. The motion passed.

Steve Baden presented a savings plan where excess funds in the RESNET checking account would be swept into a short term money market fund as part of RESNET's Union Bank of California account.

David Goldstein moved that the RESNET Executive Director enter into such an account and recommend to the RESNET Executive Committee which money market funds be directed to. After approval of the Executive Committee the Executive Director could set up the account. Daran Wastchak seconded the motion. The motion passed.

David Goldstein moved that the RESNET Board adopt the following resolution:

RESOLVED –

FIRST: that the President, or any Vice President, or the Executive Director on behalf of the corporation (herein called the "Corporation"), to establish and maintain one or more accounts, which may be margin accounts, with National Financial Services Corporation (herein called the "Brokers") for the purpose of purchasing, investing in, or otherwise acquiring, selling (including short-sales), possessing, transferring, exchanging, pledging, or otherwise disposing of, or turning to account of, or realizing upon, and generally dealing in and with

**(a) any and all forms of securities, including, but not by way of limitation, shares, stocks, bonds, debentures, notes, scrip, participation certificates, rights to subscribe, options, warrants, certificates of deposit, mortgages, evidences of indebtedness, commercial paper, certificates of indebtedness and certificates of interest of any and every kind and nature whatsoever, secured and unsecured, whether represented by trust, participation by trust, participating and/or other certificates or otherwise; and*

** (b) any and all commodities and/or contracts for the future delivery thereof, whether represented by trust, participating and/or other certificates or otherwise.*

The fullest authority at all times with respect to any such commitment or with respect to any transaction deemed by any of the said officers and/or agents to be proper in connection therewith is hereby conferred, including authority (without limiting the generality of the foregoing) to give written or oral instructions to the Brokers with respect to said transactions; to borrow money and securities and if transactions in commodities are authorized hereby to borrow commodities and/or future contracts in commodities, and to borrow such money, securities and/or future contracts in commodities from or through the Brokers, and to secure repayment thereof with the property of the Corporation; to bind and obligate the Corporation to and for the carrying out of any contract, arrangement, or transaction, which shall be entered into by any such officer and/or agent for and on behalf of the Corporation with or through the Brokers; to pay in cash or by checks and/or drafts drawn upon the funds of the Corporation such sums as may

be necessary in connection with any of the said accounts; to deliver securities; contracts and/or commodity futures to the Brokers; to order the transfer or delivery thereof to any other person whatsoever, and/or to order the transfer of record of any securities, or contracts, or titles, to any name selected by any of the said officers or agents; to affix the corporate seal to any documents or agreements or otherwise; to endorse any securities and/or contracts in order to pass title thereto; to direct the sale or exercise of any rights with respect to any securities; to sign for the Corporation all releases, powers of attorney, and/or other documents in connection with any such account, and to agree to any terms or conditions to control any such account; to direct the Brokers to surrender any securities to the proper agent or party for the purpose of effecting any exchange or conversion, or for the purpose of deposit with any protective or similar committee, or otherwise; to accept delivery of any securities; contracts, and/or commodity futures; to appoint any other person or persons to do any and all things which any of the said officers and/or agents is hereby empowered to do, and generally to do and take all action necessary in connection with the account, or considered desirable by such officer and/or agent with respect thereto.

SECOND: The Broker may deal with any and all of the persons directly or indirectly by the foregoing resolution empowered, as though they were dealing with the Corporation directly.

THIRD: That the Secretary of the Corporation be and he/she hereby is authorized, empowered and directly to certify, under the seal of the Corporation, or otherwise, to the Brokers:

(a) a true copy of these resolutions;

(b) specimen signatures of each and every person by these resolutions empowered;

(c) a certificate (which, if required by the Brokers, shall be supported by an opinion of the general counsel of the Corporation, or other counsel satisfactory to the Brokers) that the Corporation is duly organized and existing, that its charter empowers it to transfer the business by these resolutions defined, and that no limitation has been imposed upon such powers by the By-Laws or otherwise.

FOURTH: That the Brokers may rely upon any certificate given in accordance with these resolutions, as continuing fully effective unless and until the Brokers shall receive due written notice of a change in or the rescission so evidenced and the dispatch or receipt of any other form of notice shall not constitute a waiver of this provision, nor shall the fact that any persons hereby empowered ceases to be an officer of the Corporation or becomes an officer under some other title in any way affect the powers hereby conferred. The failure to supply any specimen signature shall not invalidate any transaction if the transaction is in accordance with the authority actually granted.

FIFTH: That in the event of any change in the office or powers of persons hereby empowered, the Secretary shall certify such changes to the Brokers in writing in the manner hereinabove provided, which notification, when received, shall be adequate both to terminate the powers of the persons theretofore authorized, and to empower the persons thereby substituted.

SIXTH: That the forgoing resolutions and the certificates actually furnished to the Brokers by the Secretary of the Corporation pursuant thereto, be and they hereby are made irrevocable until written notice of the revocation thereof shall have been received by the Brokers.

Daran Wastchak seconded the motion. The motion passed.

Nominations Report/Election of Officers

Michael Holtz reported that the Nominations Committee recommends nominating the current slate of officers. Michael Holtz made the motion to re-elect the current officers. Mark Jansen seconded the motion. The motion passed with Kelly Parker, David Goldstein, Lee O'Neal, and Bruce Harley abstaining.

Report of Training and Education Committee

On behalf of the Training and Education Committee, David Wilson made a motion to amend the RESNET Standards to require all raters to take the RESNET on-line rater test every three years to maintain their certification. Eric Borsting seconded the motion. The motion failed with two abstentions.

Daran Wastchak made a motion for the Training and Education Committee to re-evaluate the recommendation to require raters to take the RESNET on-line test every three years to maintain certification and to consider provisions for rater continuing education and come back to the Board with a recommendation expeditiously. Eric Borsting seconded the motion. The motion passed.

Richard Faesy made a motion that a score of 80% or better on the QA/Designee/Trainer test be considered equivalent to passing the rater test and will be recognized retroactively. Bruce Harley seconded the motion. The motion passed.

The Board requested that RESNET staff notify any individuals affected by this decision.

Report of the Quality Assurance and Ethics Committee

Ben Adams presented the report of the Quality Assurance and Ethics Committee. In 2006 RESNET staff monitored eight providers in the states of Arizona, Colorado, Nevada, Oklahoma and Virginia. In 2007 RESNET will conduct monitoring of electronic files on 100% of the providers."

Report of the Technical Committee

RESNET Formal Interpretation 2007-001:

Bruce Harley presented the Technical Committee's request that the RESNET Board adopt "RESNET Formal Interpretation 2007-001" regarding RESNET Publication 06-001 and 05-001, *Procedures for Certifying Residential Energy*

Efficiency Tax Credits for New Homes, Appendix A, Section 3, "Rule Set for Configuration of the Reference Home and Qualifying Home" (Attachment A).

Philip Fairey made a motion to approve "RESNET Formal Interpretation 2007-001" with an editorial modification to add "05-001" under the "applies to" section, and with the condition that the D.O.E. agrees that RESNET has the authority to make this interpretation. C.T. Loyd seconded the motion. The motion passed.

Proposal to RESNET Board – Notification to Client on Indoor Air Quality:

Bruce Harley presented the Technical Committee's request to adopt a disclosure form for notification to clients on Indoor Air Quality.

David Wilson moved to send the document back to the Technical Committee to be put into standards language and then presented again to the Board for a vote with suggested changes before beginning a public comment process. Richard Faesy seconded the motion.

C.T. Loyd offered a friendly amendment that the Board continue informal discussions and Philip Fairey offered a friendly amendment that the document undergo some legal review before the public comment process. Both friendly amendments were accepted by the persons that made and seconded the motion. The motion passed. Eric Borsting abstained.

Executive Session

The Board went into executive session to discuss the evaluation of the RESNET Executive Director. Philip Fairey moved that the RESNET Board of Directors accept the recommendation by the Executive Committee for a 2006 bonus for Steve Baden. Lee O'Neal seconded the motion. The motion passed.

European Union Dialogue

Eduardo Maldando, chairman of the European Union's Energy Performance in Buildings Directive Concerted Action Group made a presentation on the European Union's requirement that all buildings be rated at the time of sale or change of occupancy. Professor Maldando offered to involve RESNET formally with a dialogue with the Concerted Action Group.

International Energy Agency Dialogue

Paul Waide of the International Energy Agency explained the G-8's climate change and energy initiative and the priority that the leaders of the G-8 nationals placed upon building energy performance.

Canada Dialogue

Representatives of Canadian raters made a presentation to the board on their desire to affiliate with RESNET.

Richard Faesy made a motion that staff work with the Canadian raters and prepare and return a proposal about how RESNET can pursue and establish a relationship with the Canadians interested in establishing a RESNET presence in Canada. Philip Fairey seconded the motion. The motion passed.

Sampling Standard (Labels & Statistical Analysis)

Home Rating Label Proposal:

David Wilson made a motion to adopt the proposal submitted by staff on requiring a label on rated homes (Attachment B). Michael Holtz seconded the motion.

Philip Fairey offered a friendly amendment that the label be created in coordination with the D.O.E. National Builder Challenge program label. The friendly amendment was accepted by both David Wilson and Michael Holtz. The motion passed. Eric Borsting abstained.

Sampling Statistical Analysis Proposal:

Steve Baden presented RESNET's staff recommendation on completing a sampling statistical analysis.

Daran Wastchak moved to send the proposal back to the Sampling Committee to resolve the issue of how to raise the money to fund the statistical analysis. David Wilson seconded the motion. The motion passed.

Trademark "HERS Index"

The Board wanted it noted in the minutes that staff should pursue trade marking the term "HERS Index".

Adopt RESNET Publication 07-003 - IECC Test Suite

Philip Fairey presented the proposed RESNET Publication 07-003 "IECC Test Suite" that was developed by the RESNET Software Test Verification Task Force (Attachment C).

David Wilson moved to adopt the publication with non-substantive changes and with the addition interpretation approved by the Board. Michael Holtz seconded the motion. The motion passed. Eric Borsting abstained.

2007 RESNET Priorities

David Goldstein moved to adopt the following priorities for RESNET in 2007:

- Develop strategic business opportunities for environmental, capacity value and energy efficiency certificate trading.
- Advocate for legislative extension of new homes and commercial buildings energy efficiency tax incentives and a performance based existing homes credit.
- Adopt RESNET standards for energy audits of existing homes.
- Implement Sampling Provider Accreditation application process.
- Rater provider quality assurance monitoring
- Begin developing RESNET standard for mid and high rise multifamily and commercial buildings
- Continue international dialogue with goal of harmonizing standards
- Continue dialogue between representatives of the boards of the Building Performance Institute and RESNET on investigating the harmonizing the two organizations standards and organizations.
- Advocate removing prescriptive requirements for the performance option of the International Energy Conservation Code

Bruce Harley seconded the motion. The motion passed.

2007 RESNET Budget –

Steve Baden presented the following proposed budget for 2007:

RESNET 2007 Proposed Budget

Professional Services	**$315,000**
- Western Residential Energy Services (Steve Baden, Claudia Brovick & Kathy Spigarelli)	
- Florida Solar Energy Center	
- R.L. Martin & Associates	
- Contract to Develop New Test Questions	
- Contract to Format Standard with ANSI Standards	
Accounting	**$15,000**
Travel	**$70,000**
Supplies	**$5,000**
Other	**$217,000**
Banking Service Charge ($7,000)	
Rater Member Subscriptions to Home Energy ($9,800)	
Internet Service ($1,500)	
Postage & Delivery ($2,500)	

Telephone ($6,000)
Insurance ($3,000)
Copying & Printing ($3,200)
Conference Food & Beverage ($184,000)

Contributions **$7,000.00**

- EEBA

Total Proposed Budget $629,000

This was the second year of the two year contract with Western Residential Energy Services for the administration of RESNET. Last year the RESNET Executive Committee compared the Western Residential Energy Services contract rates with similar non-profit organizations and found it to be reasonable.

Bruce Harley made a motion to accept the proposed budget. Ken Fonorow seconded the motion. Philip Fairey offered a friendly amendment that RESNET staff re-evaluate the need for the $7000 contribution to EEBA. The friendly amendment was accepted by Bruce Harley and Ken Fonorow. The motion passed.

Adjournment

C.T. made a motion to adjourn at 5:30 p.m. Pacific, with a second from David Wilson. The motion passed.

Respectfully Submitted
Bruce Harley, Secretary

Attachment A

RESNET Formal Interpretation 2007-001

Proponent:
RESNET Technical Committee

Applies to:
RESNET Publication 06-001 and 05-001, *Procedures for Certifying Residential Energy Efficiency Tax Credits for New Homes,* Appendix A, Section 3, "Rule Set for Configuration of the Reference Home and Qualifying Home."

Interpretation:
Specifications for the configuration and operation of the Reference and Qualifying Homes that are not explicitly included in RESNET Publication 06-001 and 05-001 shall be as specified by Sections 303.4 and 303.5 of the *2006 Mortgage Industry National Home Energy Rating Systems Standards*.

Explanation:
This interpretation is required to provide complete and unambiguous specifications for the configuration and operation of the Reference and Qualifying Homes for the purposes of tax credit qualification. This applies generally to software providers.

Attachment B

RESNET Residential Energy Services Network — Setting the STANDARD for QUALITY

To: RESNET Board of Directors

From: Steve Baden
Executive Director

Re: Home Rating Label

Date: January 26, 2007

The new sampling accreditation standard adopted by the RESNET Board requires that:

603.1.4.2 Every home subjected to this sampling protocol shall be provided with a label in accordance with Section 303.3 of these standards, which contains the following statement: "This home has been certified using a sampling protocol in accordance with RESNET Standards. As such, some or all of the energy features of this home may or may not have been individually inspected or tested." This label shall be located on the electrical panel and the font shall be a minimum of 10 points.

In addition the 2006 International Energy Conservation Code (IECC) requires that a certificate regarding compliance to the energy code be placed on the electrical panel. The IECC requirement states:

401.3 Certificate. A permanent certificate shall be posted on or in the electrical distribution panel. The certificate shall be completed by the builder or registered design professional. The certificate shall list the predominant R-values of insulation installed in or on ceiling/roof, walls, foundation (slab, basement wall, crawlspace wall and/or floor) and ducts outside conditioned spaces; U-factors for fenestration; and the solar heat gain coefficient (SHGC) of fenestration. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the type and efficiency of heating, cooling and service water heating equipment.

At its meeting on December 20, 2006 the RESNET Board voted that RESNET adopt a label requirement for all homes rated in accordance with the RESNET Standard. RESNET staff was directed to submit a proposal to the Board at its

annual meeting in San Diego in February, 2007. The following is RESNET staff's proposal.

Home Energy Raters will be required to affix a label on the electrical distribution panel of all rated homes. The label will be similar to the yellow energy guide currently found on major appliances. A graphic of the HERS Index will be displayed indicating "200" as the Standard Home and "0"as a Net Zero Energy Home. The index score of the rated home will be indicated on the Index. In addition, projected energy costs from the HERS Report will also be displayed.

The label will include the following information:

- If the home was independently inspected and tested it will include the following language. "This home was rated according to the home energy rating procedures adopted by RESNET."
- If the home is sampled it will include the following language: "This home has been certified using a sampling protocol in accordance with RESNET Standards. As such, some or all of the energy features of this home may or may not have been individually inspected or tested."
- The information required by the 2006 IECC
- The logo and web site of RESNET and the applicable rating provider

The rating software will be required to produce a label for the rater to print and affix on the home's electrical panel.

The RESNET Board is asked to approve this proposal. Upon approval, staff will develop several graphic options for the Board to consider.

RESNET staff is proposing that the labeling of homes that are not sampled initially be voluntary. An amendment to the RESNET Standard is necessary to make this mandatory.

This is not intended to be an unnecessary or costly burden on the rating industry. Instead it is intended to be used as a marketing tool. It will provide home buyers exposure to both the rating process and to RESNET. It will provide a rater the opportunity to offer two services as it will also meet the IECC requirement.

Attachment C

Procedures for Verification of International Energy Conservation Code Performance Path Calculation Tools

RESNET Publication No. 07-003

February 2007

1 Introduction

With the support of the U.S. Department of Energy, the National Renewable Energy Laboratory (NREL) and the Florida Solar Energy Center (FSEC), RESNET created a software verification committee to serve as an advisory group to develop a rule set for tax credit qualification purposes and to develop test suites for software to be used for verification of tax credits, home energy ratings, and the IECC. The committee was composed of representatives of National Renewable Energy Laboratory (NREL), Pacific Northwest National Laboratory (PNNL), Florida Solar Energy Center (FSEC), RESNET accredited rating software program providers, ICF Consulting, and individuals who were instrumental in development of the California ACM. Members of the committee include:

- Steve Baden, RESNET
- Patrick Bailey, GeoPraxis (Developer of the EnergyCheckup rating tool software)
- Dennis Barley, NREL
- Philip Fairey, Florida Solar Energy Center (developer of the EnergyGauge® rating tool software)
- Dean Gamble, ICF Consulting
- Thomas Hamilton, California Home Energy Efficiency Rating System
- Michael Holtz, Architectural Energy Corporation (developer of the REM/Rate rating tool software,)
- Ron Judkoff, NREL
- Maria Karpman, Taitem Engineering (developer of the TREAT rating tool software)
- Ken Nittler, EnerComp (Developer of the MicroPass rating tool software)
- Danny Parker, Florida Solar Energy Center
- Paul Reeves, E-Star Colorado (developer of the E-Star rating tool software)
- Dave Roberts, Architectural Energy Corporation
- Ian Shapiro, Taitem Engineering
- Todd Taylor, Pacific Northwest National Laboratory
- Bruce Wilcox, Berkeley Solar Group

2 Procedures for Verification of International Energy Conservation Code Performance Path Calculation Tools

Because the performance path (Section 404) of the International Energy Conservation Code (IECC) is based on comparative performance analysis (Proposed Home as compared with the Standard Reference Design Home), computer software modeling is required. In order to ensure the accuracy and comparability of IECC Performance Path Calculation Tools, software vendors seeking RESET accreditation shall comply with the following procedures.

2.1 National Standard

Section 404 of the IECC, hereinafter referred to as "the Code," shall be the national standard for the development and use of IECC performance compliance software tools. Section 404 of the Code provides the technical basis for the development of IECC performance compliance software tools that determine Codecompliance. This document describes a set of verification tests that are required for RESNET accreditation of IECC performance compliance software tools.

2.2 Software Verification Test Suite

The RESNET Software Verification Committee has defined a suite of software tests for use in verifying IECC performance compliance software tool accuracy and comparability. The RESNET Board of Directors has adopted this test suite as the verification tests that shall be used by RESNET to accredit computerized IECC performance compliance tools. The RESNET software verification test suite includes the following tests:

2.2.1 Tier one of the HERS BESTEST – HERS BESTEST was developed by the National Renewable Energy Laboratory (NREL) for testing the building load prediction accuracy of simulation software. (See Section 3.1.)

2.2.2 IECC Code Reference Home auto-generation tests – These tests verify the ability of the software tool to automatically generate the IECC Standard Reference Design Home. (See Section 3.2.)

2.2.3 HVAC tests – These tests verify the accuracy and consistency with which software tools predict the performance of HVAC equipment, including furnaces, air conditioners, and air source heat pumps. (See Section 3.4.)

2.2.4 Duct distribution system efficiency tests – These tests verify 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 Section 3.5.)

2.2.5 Hot water system performance tests – These tests determines the ability of the software to accurately predict hot water system energy use. (See Section 3.6.)

2.3 Process for Accrediting Software Programs

The RESNET accreditation process provides a suite of verification tests to certify that rating 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 program with which the tests were conducted to RESNET. This information may be released by RESNET for review by any party, including competing software developers. This process is expected to result in compliance without a costly bureaucratic review and approval process.

2.4 Process for Exceptions and Appeals

RESNET has established an appeals process that software developers may use if their software is so unique that they cannot be accurately tested through the RESNET software testing procedures. The elements of this appeal process are:

- The software provider's documentation of how the software or qualification program meets or exceeds the criteria established in the RESNET software verification procedures.
- The software developer's justification and documentation as to why the software is so unique that it cannot comply with the RESNET software tool testing protocols.
- Independent evaluation of the software tool by RESNET in collaboration with independent experts. Based upon the results of the evaluation, RESNET may certify that the software tool meets or exceeds the performance criteria of RESNET's software tool verification procedures.

3 Test Suite Specifications and Acceptance Criteria

3.1 HERS BESTEST

Specifications, instructions and acceptance criteria (Tables 4-1, 4-2 and 4-4 of Volume 2 of the document) for the HERS BESTEST are found in the following document:

Judkoff, R. and J. Neymark, 1995. "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST)," Vol. 1 and 2, Report No. NREL/TP-472-7332, National Renewable Energy Laboratory, Golden, Colorado 80401-3393. (Also available online at http://www.nrel.gov/publications/.)

Since the home configurations from this test suite are used for most of the other HERS software verification tests, it is highly recommended that this set of tests be completed prior to conducting the other verification tests prescribed by this procedure.

3.2 IECC Code Reference Home Auto-Generation Tests

This section contains the Reference Home auto-generation test suite for IECC performance compliance tools. The test cases in this proposed test suite are designed to verify that software tools automatically generate accurate Standard Reference Designs given only the building information from the Proposed homes.

3.2.1 Minimum Reporting Requirements

Software tools applying for verification 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. In some cases, the data needed to verify accuracy is of no interest or value to the end-user of the software, but in any case, the software tool must generate it. At a minimum, software tools applying for accreditation must report the following values for the 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 ($SHGC_o$)[1] 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)
7. Specific leakage area (SLA) for the building, by zone or as SLA_o[2], as appropriate
8. Attic net free ventilation area (ft^2)
9. Crawlspace net free ventilation area (ft^2), if appropriate
10. Exposed masonry floor area and carpet and pad R-value, if appropriate
11. Heating system labeled ratings, including AFUE, COP, or HSPF, as appropriate.
12. Cooling system labeled ratings, including SEER or EER, as appropriate.
13. Thermostat schedule for heating and cooling
14. Air distribution system characteristics, including locations of all supply and return ducts and the air handler units, supply and return duct R-values, and supply and return duct air leakage values (in cfm_{25}).[3]

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[1] The overall solar heat gain coefficient ($SHGC_o$) 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.

[2] SLA_o 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.

15. Mechanical ventilation kWh/yr, if appropriate

Software tools must have the ability to recreate or store the test case Standard Reference Designs as if they were Proposed Homes such that they also can be simulated and evaluated as the Proposed Homes.

3.2.2 Auto-generation Test Case Descriptions

Test Case1. HERS BESTEST case L100 building configured as specified in the HERS BESTEST procedures, 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.

Test Case 2. HERS BESTEST 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.

Test Case 3. HERS BESTEST 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.

Test Case 4. HERS BESTEST case L324 configured as specified as in the HERS BESTEST 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.

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

3.2.3 Acceptance Criteria

3.2.3.1 Test Cases 1 – 4.

For test cases 1 through 4 the values contained in Table 3.2.3.1 shall be used as the acceptance criteria for software tool accreditation. For Standard Reference Design building components marked by an asterisk (*), the acceptance criteria may include a range equal to ± 0.05% of the listed value. For all other Reference Home components the listed values are exact.

Table 3.2.3.1 Acceptance Criteria for Test Cases 1 – 4

Reference Home Building Component	Test 1	Test 2	Test 3	Test 4

[3] cfm_{25} = cubic feet per minute of air leakage to outdoors at a pressure difference between the duct interior and outdoors of 25 Pa.

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	2.0	2.0	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)				
IECC 2004 (IECC 2006)	69.26 (67.50)	69.26 (67.50)	69.26 (67.50)	102.63 (50.01)
South window area* (ft^2)				
IECC 2004 (IECC 2006)	69.26 (67.50)	69.26 (67.50)	69.26 (67.50)	102.63 (50.01)
East window area* (ft^2)				
IECC 2004 (IECC 2006)	69.26 (67.50)	69.26 (67.50)	69.26 (67.50)	102.63 (50.01)
West window area* (ft^2)				
IECC 2004 (IECC 2006)	69.26 (67.50)	69.26 (67.50)	69.26 (67.50)	102.63 (50.01)
Window U-Factor	0.40	0.65	1.20	0.35
Window $SHGC_o$ (heating)	0.4675	0.34	0.34	0.4675
Window $SHGC_o$ (cooling)	0.385	0.28	0.28	0.385
SLA_o (ft^2/ft^2)				
IECC 2004 (IECC 2006)	0.00048 (0.00036)	0.00048 (0.00036)	0.00048 (0.00036)	0.00048 (0.00036)
Internal gains* (Btu/day)	66,840	66,840	62,736	107,572
Labeled heating system rating and efficiency	AFUE = 78%	HSPF = 7.7	HSPF = 7.7	AFUE = 78%
Labeled cooling system rating and efficiency	SEER = 13.0	SEER = 13.0	SEER = 13.0	SEER = 13.0

Comment [PF1]: This area can be problematic. Are we going to do multiple versions of the code? IECC 2004 and IECC 2006 can differ here. Original values would apply for IECC 2004 and values in parenthesis would apply for IECC 2006.

Comment [PF2]: These values are correct for IECC 2004 but incorrect for IECC 2006. Should we do two versions?

Reference Home Building Component	Test 1	Test 2	Test 3	Test 4
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)

3.2.3.2 Test Case 5.

Test case 5 requires that each of the Standard Reference Design for test cases 1-4 be stored or recreated in the software tool as Proposed Homes and simulated as any other rated home would be simulated. If the resulting Proposed Home is correctly configured to be identical to its appropriate Standard Reference Design, code compliance calculations arising from normal operation of the software tool should produce virtually identical scoring criteria for both the Standard Reference Design and the Proposed Home for this round of tests. For test case 5, the energy use e-Ratio shall be calculated separately from the simulation results for heating and cooling, as follows:

e-Ratio = (Proposed Home energy use) / (Standard Reference Design energy use)

Acceptance criteria for these calculations shall be ± 0.5% of 1.00. Thus, for each of the preceding test cases (1-4), 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.

3.3 HVAC Tests

3.3.1 Required Capabilities

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

3.3.2 System Types.

The following system types that must 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. "Dual fuel" systems that utilize an electric air or ground source heat pump for primary heating and fuel for backup heating. An example of this would be an electric air source heat pump with a gas 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 above optional system types. The following table lists the efficiency metrics that are reported by manufacturers, which shall be used for each system type.

Table 3.4.2 HVAC Equipment Efficiency Metrics

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

3.3.3 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.

Table 3.4.3 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	0.941*(1/(SEER/3.413))

DOE-2 Keyword:	Description (units)	Value
	Ratio compressor only, (1/cop)	
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, (^{o}F)	40^o
CRANKCASE-HEAT	Refrigerant crankcase heater power, (kW)	0.05
CRANK-MAX-T	Temperature above which crankcase heat is deactivated, (^{o}F)	50^o
MIN-HP-T (F)	Minimum temperature at which compressor operates, (^{o}F)	0^o
MAX-HP-SUPP-T	Temperature above which auxiliary strip heat is not available, (^{o}F)	50^o
MAX-SUPPLY-T (heating, heat pump)	Maximum heat pump leaving air temperature from heating coil, (^{o}F)	105^o
MAX-SUPPLY-T (heating, natural gas furnace)	Maximum gas furnace leaving air temperature from heating coil, (^{o}F)	120^o
FURNACE-AUX	Natural gas furnace pilot light energy consumption, (Btu/h)	100
MIN-SUPPLY-T (cooling)	Minimum cooling leaving air temperature from cooling coil, (^{o}F)	55^o
SUPPLY-KW	Indoor unit standard blower fan power, (kW/cfm)	0.0005
SUPPLY-DELTA-T	Air temperature rise due to fan heat, standard fan, (^{o}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, (^{o}F)	1.185
COIL-BF	Coil bypass factor, (dimensionless)	0.241
Other parameters:		

DOE-2 Keyword:	Description (units)	Value
Part load performance curves	Compressor part load performance curves	Henderson, et.al.[4]
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)

3.3.4 Test Description and Acceptance Criteria

The following test suites represent tests that tools must pass to be accredited. All tests are to be performed using the L100 building case described by the HERS BESTEST procedures.[5]

For each test case, acceptance criteria are provided. These criteria are based on reference results from 6 tools, which are capable of detailed hourly building simulation and HVAC modeling computations.[6] The criteria are established as the greater of the 90% confidence interval using the student t-test criteria or 10% of the mean results for the 6 sets of reference results. In order to pass a specific test, tools must 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 must provide for climate adjusted equipment performance factors in order to fall within the acceptance criteria for these tests. Methods of adjusting the manufacturer's nameplate ratings to account for climate dependent performance have been reported.[7]

3.3.4.1 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.

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[4] 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.

[5] Judkoff, R. and J. Neymark, 1995. "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST)," Vol. 1 and 2, Report No. NREL/TP-472-7332, National Renewable Energy Laboratory, Golden, Colorado 80401-3393. (Also available online at http://www.nrel.gov/publications/.)

[6] Two DOE-2.1E tools, two DOE-2.2 tools, Micropas version 6.5 and TRNSYS version 15.

[7] 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/)

Table 3.4.4.1 (1) 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

Table 3.4.4.1 (2) Air Conditioning System Acceptance Criteria

Test #	Average Change From Base Case	Low Acceptance Criteria	High Acceptance Criteria
HVAC1a	Base case	---	---
HVAC1b	-19.3	-21.2%	-17.4%

3.3.4.2 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.

Table 3.4.4.2 (1) 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%

Table 3.4.4.2 (2) Gas Heating System Acceptance Criteria

Test #	Average Change From Base Case	Low Acceptance Criteria	High Acceptance Criteria
HVAC2a	Base case	---	---
HVAC2b	-12.9%	-13.3%	-11.6%

Table 3.4.4.2 (3) 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

Table 3.4.4.2 (4) Electric Heating System Acceptance Criteria

Test #	Average Change From Base Case	Low Acceptance Criteria	High Acceptance Criteria
HVAC2c	Base case	---	---
HVAC2d	-22.9%	-29.0%	-16.7%
HVAC2e	61.3%	41.8%	80.8%

3.4 Duct Distribution System Efficiency (DSE) Tests (Suite 3)

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 tests.

3.4.1 Test Description

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 shall 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) shall 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.[8] 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 3.5.3(1) and 3.5.4(1)) shall be entered as R=1.5 while the insulated ducts (R=6 in tables) shall be entered as R=7.

For the heating comparison test cases (Table 3.5.3(1)), which assume a basement, use the HERS BESTEST Case L322 home. The basement shall be unconditioned, have a floor area equal to the main floor area (1539 ft^2) and have R-11 insulation in the floor joists of the main floor with a framing fraction of 13%. The basement case has no basement wall insulation. For the cooling comparison test cases (Table 3.5.4(2)), use the HERS BESTEST case L100 home.

3.4.2 Acceptance Criteria

The acceptance criteria for these tests were established using ASHRAE Standard 152-04, using the spreadsheet tool constructed for the U.S. DOE *Building America* program by Lawrence Berkeley National Laboratory (LBNL).[9] 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

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

[9] See http://www.eere.energy.gov/buildings/building_america/benchmark_def.html

- 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 3.5.3(2) and 3.5.4(2)) using the following calculation:

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

Acceptance criteria were then established as this target delta plus and minus 5% to yield the values given in Tables 3.5.3(2) and 3.5.4(2) for heating and cooling test minimum and maximum acceptance criteria, respectively.

3.4.3 Heating Energy Tests

Table 3.5.3 (1) 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 air film resistance in detail, then these air film resistances should be added.						

Table 3.5.3 (2) Heating Energy DSE Comparison Test Acceptance Criteria

Test #	Target Delta* Heating Energy Relative to HVAC3a	Minimum Delta* Heating Energy	Maximum Delta* Heating Energy
HVAC3a	Base case	---	---
HVAC3b	26.4%	21.4%	31.4%
HVAC3c	7.5%	2.5%	12.5%
HVAC3d	20%	15%	25%
* Delta = % Change in energy use = ((alternative – base case) / (base case)) * 100			

3.4.4 Cooling Energy Tests

Table 3.5.4 (1) 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 3.5.4 (2) Cooling Energy DSE Comparison Test Acceptance Criteria

Test #	Target Delta* Cooling Energy Relative to HVAC3e	Minimum Delta* Cooling Energy	Maximum Delta* Cooling Energy
HVAC3e	Base case	---	---
HVAC3f	31.2%	26.2%	36.2%
HVAC3g	11.5%	6.5%	16.5%
HVAC3h	26.1%	21.1%	31.1%
* Delta = % Change in energy use = ((alternative – base case) / (base case)) * 100			

3.5 Hot Water System Performance Tests

Hot water system tests are designed to determine if IECC performance compliance software tools accurately account for both the hot water usage rate (gallons per day) and the climate impacts (inlet water temperatures) of hot water systems. The tests are limited to standard gas-fired hot water systems and cannot be used to evaluate solar hot water systems, heat pump hot water systems, hot water systems that recover heat from air conditioner compressors (heat recovery or de-super heater systems), or other types of hot water systems. In addition, distribution losses associated with hot water distribution systems are not covered by this test.

3.5.1 Test Description

The following table provides summary specifications for the six required hot water tests. The tests are segregated into two sets of three tests – one set of cold climate tests (Duluth, MN) and one set of hot climate tests (Miami, FL).

Table 3.6.1 Summary Specifications for Standard Hot Water Tests

Test Number	System Type	Climate Location	System Efficiency	Number of Bedrooms
DHW-MN-56-2	40 gal, gas	Duluth, MN	EF = 0.56	2
DHW-MN-56-4	40 gal, gas	Duluth, MN	EF = 0.56	4
DHW-MN-62-2	40 gal, gas	Duluth, MN	EF = 0.62	2
DHW-FL-56-2	40 gal, gas	Miami, FL	EF = 0.56	2
DHW-FL-56-4	40 gal, gas	Miami, FL	EF = 0.56	4
DHW-FL-62-2	40 gal, gas	Miami, FL	EF = 0.62	2

Additional specifications used in the creation of the reference results that establish the hot water system test acceptance criteria are as follows:

3.5.1.1 Hot Water Draw Profile

The hot water draw profile is as specified by Table 3, ASHRAE Standard 90.2, as given in Table 3.6.1.1 below:

Table 3.6.1.1 Hourly Hot Water Draw Fraction for Hot Water Tests

Hour of Day	Daily Fraction	Hour of Day	Daily Fraction	Hour of Day	Daily Fraction
1	0.0085	9	0.0650	17	0.0370
2	0.0085	10	0.0650	18	0.0630
3	0.0085	11	0.0650	19	0.0630
4	0.0085	12	0.0460	20	0.0630
5	0.0085	13	0.0460	21	0.0630
6	0.0100	14	0.0370	22	0.0510
7	0.0750	15	0.0370	23	0.0510
8	0.0750	16	0.0370	24	0.0085

3.5.1.2 Inlet Mains Temperature

The cold-water inlet mains temperatures to the hot water system are calculated in accordance with the following formula:[10]

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

where:

T_{mains} = mains (supply) temperature to domestic hot water tank (ºF)

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

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

[10] NREL, "Building America Research Benchmark Definition." National Renewable Energy Laboratory, Golden, CO, December 29, 2004. May be found online at: http://www.eere.energy.gov/buildings/building_america/pa_resources.html

0.986 = degrees/day (360/365)
day# = Julian day of the year (1-365)
offset = 6°F
ratio = 0.4 + 0.01 ($T_{amb,avg}$ – 44)
lag = 35 – 1.0 ($T_{amb,avg}$ – 44)

3.5.1.3 Additional TRNSYS Simulation Parameters

Additional inputs for TRNSYS reference result simulations are as follows:

- Rated Power 40,000 Btu/hr
- Recovery efficiency: 0.78
- Tank UA for EF=0.56 system: 10.79 Btu/hr-F
- Tank UA for EF=0.62 system: 7.031 Btu/hr-F
- Tank set point temperature: 120 F
- Tank space temperature ("loss temp"): 75 F
- Tank stratification: 15 equal nodes
- Simulation time step: 1/16th hour

3.5.2 Acceptance Criteria

In each of the two sets of three test cases, the first test listed (DHW-xx-56-2) is the base case and the other two cases are the alternative cases. There are two metrics used for acceptance criteria a difference metric (delta) and an absolute metric (MBtu). The delta metric is the % change in energy use for the alternative cases with respect to the base case, which is determined as follows:

% Change = (alternative - base) / (base) * 100

The absolute metric is the projected hot water energy use given in millions of Btu (site MBtu). The acceptance criteria given in Table 3.6.2 below are determined from reference results from three different software tools – TRNSYS version15, DOE-2.1E (v.120) as used by EnergyGauge USA version 2.5, and RemRate version 12. Minimum and maximum acceptance criteria are determined as the 99% confidence interval for these reference results using the student t-test.

Table 3.6.2 Acceptance Criteria for Hot Water Systems Tests

Case	Mean	St Dev	99%CI	Minimum	Maximum
MN,0.56,4 (delta)	29.3%	0.58%	2.85%	26.5%	32.2%
MN,0.62,2 (delta)	-9.3%	0.51%	2.49%	-11.8%	-6.8%
FL,0.56,4 (delta)	24.1%	1.02%	5.01%	19.1%	29.1%
FL,0.62,2 (delta)	-13.6%	1.19%	5.87%	-19.5%	-7.7%
MN,0.56,2 (MBtu)	20.13	0.38	1.89	18.24	22.02
FL,0.56,2 (MBtu)	12.69	0.36	1.76	10.92	14.45
MN-FL (MBtu)	7.44	0.40	1.95	5.49	9.39