RESNET
Residential Energy Services Network

Setting the STANDARD for QUALITY

Results of the Electronic Ballot of the RESNET Board of Directors on Submitting Home Performance Analyst Standard to Public Review/Comment

The following are the results of the RESNET Board of Directors ballot on submitting the draft Home Performance Analyst Standard to the public review and comment process:

Shall the RESNET Board of Directors authorize that the August 14, 2008 draft of the joint RESNET/BPI Home Performance Analyst Standard recommended by the RESNET Technical Committee (Attachment A) be submitted to the RESNET standard review and comment process?

Yes (18)	**No (0)**	**Abstain (0)**	**Not Voting (3)**
Ben Adams			Tom Hamilton
Steve Byers			Erin Wiggins
Dennis Creech			David Wilson
Richard Faesy			
Philip Fairey			
David Goldstein			
Andy Gordon			
Bruce Harley			
Michael Holtz			
Mark Jansen			
C.T. Loyd			
Lee O'Neal			
Greg Nahn			
Kelly Parker			
Bill Prindle			
Robert Scott			
Daran Wastchak			
Barb Yankie			

The draft standard has been authorized to be submitted to the public review and comment process.

Attachment A

Standard for Conducting a Comprehensive Home Energy Audit

FIRST EDITION Fifth draft as edited by RESNET ..... August 2008

BPI/RESNET Board of Standards

Mr. Laverne Dalgleish (Co-chair) ..... Building Professionals Consortium

Mr. Philip Fairey (Co-chair) ..... Florida Solar Energy Center

BPI/RESNET Committee on Standards

Mr. Jim Fitzgerald (Chair) ..... Conservation Services Group

Mr. XXX .....XXX Corp

Foreword

The Standard for Conducting a Comprehensive Home Energy Audit outlines the requirements for conducting a comprehensive home performance audit. It specifies how to conduct analysis, test the home, and prepare a scope of work (including specifications for post-work testing).

The selection of measures by the customer and the installation of measures by the contractor(s) are beyond the scope of the standard. The standard is intended to be used in support of building performance programs, although specific program requirements are not part of this document.

The standard is based largely on existing national standards and draws on documents from the Building Performance Institute (BPI) and the Residential Energy Services Network (RESNET). The two organizations set out to develop a standard that describes an energy audit as performed by an individual qualified as both a BPI Building Analyst and a RESNET Rater. A person certified as a Home Performance Auditor (HPA) is qualified to operate in both capacities. Technical representatives of BPI and RESNET met and reviewed the organizations' requirements for Building Analyst and Rater and determined that the requirements for both positions substantially overlapped, with relatively small categories of skills and knowledge specific to one or the other. Combining the contents of the two organizations' documents provided the basis for a single standard encompassing the requirements of both organizations. Content covered in detail in the RESNET Mortgage Industry National Home Rating Systems Standards is included by reference and not duplicated here.

The content of the standard was updated from earlier versions of the Building Analyst (BA) standard where subject matter was within the scope of a current national standard or published research. Notably, the ventilation requirements and specifications for combustion appliance testing include changes from earlier versions of the BA standard. Explicit steps are included here to reduce misrepresentation.

In this standard, other standards and research results are generally referenced rather than paraphrased. The standard must be used in conjunction with these other referenced standards, as outlined in Section 2, and with all appropriate codes.

This standard is not structured as a handbook or field guide but instead is a reference tool that may provide the basis for handbooks and training materials. It does not include instructional charts, graphics, and background information.

Table of Contents

1. Scope

1.1. This standard provides the requirements and sets forth the test methods for conducting a comprehensive home energy audit.

1.2. This standard includes requirements for analyzing the home, testing the home, rating the home, and developing a scope or work for the home.

1.3. This standard is applicable to low-rise residential buildings, both single- and multi-family and to both new and existing homes.

1.4. This standard does not specify requirements for installation of measures included in the scope of work nor for confirmation of proper installation.

1.5. Compliance with this standard may require the use of tools and equipment and does not purport to cover all the health and safety issues regarding the use of any tools and equipment. The user shall consult the manufacturer's instructions or other standards on proper use.

1.6. This standard is not intended to supersede or replace any applicable international, national, state, or local code. This standard shall be implemented in a manner consistent with all applicable codes as interpreted by the authority having jurisdiction.

1.7. Implementation or acceptance of a Comprehensive Home Energy Audit shall not constitute shall not constitute any warranty, expressed or implied, regarding potential problems that lie outside the scope of expertise of the Home Performance Auditor.

2. References

The documents listed below are referenced in the text of this standard. There are two types of references as described below, and those that may be referenced within a scope of work using a citation called "installation" references.

2.1. **Embedded references**. The Home Performance Auditor (HPA) is required to utilize these standards, as applicable, in whole or in part, in order to carry out the energy audits.

Documents Published by the Residential Energy Services Network (RESNET)
P.O. Box 4561, Oceanside, CA 92052-4561 USA
Telephone: (760) 806-3448; Fax: (760) 806-9449
www.resnet.us

2006 Mortgage Industry National Home Energy Rating Systems Standards

Documents Published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE)
1791 Tulie Circle N.E., Atlanta, GA 30329 USA

Telephone: (800) 527-4723; Fax: (404) 321-5478
www.ashrae.org
ANSI/ASHRAE 103-1993
***ASHRAE 62.2-2007,* Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings**
ASHRAE Standard 119-1998 (RA-2004)
ASHRAE Standard 136-????

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1 Batterymarch Park, Quincy, MA 30169-7471 USA
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NFPA 54-2006, ANSI Z223.1-2006 National Fuel Gas Code
NFPA 31 DATE
NFPA 211 DATE
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Place du Portage, III, 6B1Gatineau, Quebec, K1A 1G6 Canada
Telephone: (819) 956-0425; Fax: (819) 956-5740
www.pwgsc.gc.ca/cgsb
CAN/CGSB-51.71-2005 Depressurization Test

IECC 2006
OSHA 29 CFR 1926.62, 29 CFR 1926.1101

2.2. **Installation references.** The home performance auditor is required to use these references, as applicable, in whole or in part, in the preparation of a scope of work, or may cite these references directly in the scope of work.

Documents Published by the American Society for Testing and Materials (ASTM)
100 Barr Harbour Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 USA
Telephone: (610) 832-9585; Fax: (610) 832-9555
www.astm.org
***ASTM E 2112-07,* Standard Practice for Installation of Exterior Windows, Doors and Skylights**
ASHRAE 152-2004, Annex A
EEBA Builder Guides
2006 IRC, Sections R408.3 and R1102.1
UL 2034, IAS 6-96, or CSA 6.19-01 (listing only)
ACCA Manual J
ACCA Manual S
Title X, EPA 40 CFR Rules
ARI certification directory www.ahridirectory.org
NEC 324.4 1987

3. Terms and definitions

air-free carbon monoxide: A measurement of carbon monoxide (CO) in an air sample or flue gas that estimates the amount of excess air (oxygen, O_2) in the sample. The measurement incorporates an adjustment to the as-measured CO ppm (parts per million) value to simulate oxygen-free conditions in the sample. (See "as-measured carbon monoxide.")
ANSI: American National Standards Institute.

as-measured carbon monoxide: A direct measurement of carbon monoxide CO in a sample of air or flue gas, usually measured in ppm (parts per million) units. (See "air-free carbon monoxide.")
atmospheric-vented: An appliance using a natural-draft venting system.
atmospheric pressure: The weight of air and its contained water vapor on the surface of the earth; at sea level, this pressure is 14.7 pounds per square inch.
backdraft: Sustained downdraft during burner operation.
barometric damper: See "draft regulator."
barometric draft regulator: See "draft regulator."
boiler: A space heating appliance that heats water with hot combustion gases that pass through a heat exchanger.
base load: An estimate of fuel consumption that does not include cooling or heating.
CAZ: See "Combustion appliance zone"
carbon monoxide (CO): An odorless, colorless gas that can cause illness or death.
carbon monoxide emissions: Carbon monoxide (CO) resulting from combustion as measured in ppm (parts per million. The measurement of CO emissions in flue gas requires a sample to be taken before dilution air enters the venting system. (See "air-free carbon monoxide" and "as-measured carbon monoxide.")
category I fan-assisted gas appliance: An appliance that operates with (1) negative static pressure in the vent, (2) a temperature that is high enough to avoid condensation in the vent, and (3) an integral fan that draws a controlled amount of combustion supply air through the combustion chamber.
category I gas appliance: An appliance that operates with negative static pressure in the vent and a temperature high enough to avoid condensation in the vent.
category III gas appliance: An appliance that operates with positive static pressure in the vent and a temperature high enough to avoid condensation in the vent.
category IV gas appliance: An appliance that operates with positive static pressure in the vent and a temperature low enough to cause sustained condensation in the vent.

chimney flue: A passageway in a chimney intended to convey combustion gases to the outdoors.

combustion appliance zone: A contiguous air volume within a building that contains a combustion appliance; the zone may include, but is not limited to, a mechanical closet, mechanical room, or the main body of a house, as applicable.

common vent: The portion of a vent or chimney through which pass products of combustion from more than one appliance.
comprehensive home energy audit: A comprehensive evaluation of a home to determine its existing performance through visual inspection, measurement, performance testing, and energy simulation and analysis. The evaluation identifies improvement measures and repairs to the home.
conditioned space: Any directly conditioned space or indirectly conditioned space, as defined in this standard.

dilution air: Air that enters a draft hood or draft regulator from the room in which the appliance is located.
directly conditioned space: A space within a building that is provided with heating and/or cooling using equipment and distribution systems are capable of maintaining 65°F or higher at heating design conditions and 80°F or lower at cooling design conditions, or a space that communicates directly with such a space.

direct-vent appliance: A combustion appliance for which all combustion gases are vented to the outdoors through an exhaust vent pipe and all combustion supply air is vented to the combustion chamber from the outdoors through a separate, dedicated supply-air vent.
downdraft: Air flow from a chimney or venting system into an enclosed building space.

draft: A pressure difference that causes combustion gases or air to move through a vent connector, flue, chimney, or combustion chamber.
draft diverter: See "draft hood."
draft fan: A mechanical fan installed in a vent connector to augment the natural draft in gas- and oil-fired combustion appliances.
draft hood: A nonadjustable device built into an appliance or a part of a vent connector that is intended to (1) permit the escape of flue gases in the event of a blockage or backdraft; (2) prevent a downdraft of outdoor air from entering the combustion chamber of an appliance; (3) reduce the effect of the chimney's stack action; and (4) lower the dew point temperature of the flue gas by the infusion of room air.
draft regulator: A self-regulating damper attached to a chimney or vent connector for the purpose of controlling draft: A draft regulator can reduce draft; it cannot increase draft.
excess air: Air supplied to a burner in excess of the amount needed for complete combustion.
fan-assisted combustion: A combustion appliance with an integral fan that draws combustion supply air through the combustion chamber.
flame rollout: a condition in which burner flames discharge from the cabinet of a combustion appliance.

forced draft: A venting system for which a fan installed at the combustion appliance moves combustion gases to the outdoors with positive static pressure in the vent pipe; the vent pipe must be air-tight.
furnace: A space heating appliance that heats indoor air with hot combustion gases that pass through a heat exchanger.
home performance analysis: See **comprehensive home energy audit**.

Home Performance Auditor (HPA)***:*** A person certified by RESNET and BPI to conduct comprehensive home energy audits.

HVAC: Heating, Ventilation and Air Conditioning.

IECC: International Energy Conservation Code.

inches of water column (IWC): A unit of pressure difference; 1 IWC = 250 Pascals (see "Pascal.")
indirectly conditioned space: A space within a building that is not directly conditioned, but meets one of the following criteria: (1) the area-weighted U-factor of the boundary between it and directly conditioned space exceeds that of the boundary between it and the outdoors or the ground, where U = sum (UA)/sum(A)x; (2) air to or from directly conditioned spaces is mechanically transferred at a rate exceeding 3 air changes per hour; or (c) any unvented basement or crawl space that contains heating equipment or distribution systems, and for which 50% or more of the floor separating it from conditioned space has no thermal insulation installed.

induced combustion: See "fan-assisted combustion."
induced draft: A venting system in which a fan, installed at or near the termination point of the vent pipe, moves the combustion gases to the outdoors using negative static pressure in the vent pipe.
IRC: International Residential Code.

isolated combustion appliance zone: A combustion appliance zone that is not a part of, nor directly connected to, habitable space. It is either outdoors, or is a mechanical room or attached garage that is supplied with outdoor combustion air and separated from habitable space, and which complies with the criteria in Section E.7 of this standard.

mitigate: Reduce, lessen, decrease, make less harmful or problematic.

natural draft venting system: A venting system that relies on buoyancy to move combustion gases to the outdoors.
NIOSH: National Institute for Occupational Safety and Health.

OSHA: Occupational Safety and Health Administration.

Pascal (Pa): The metric unit of pressure equaling 1 Newton per square meter, or 0.004 inch W.G..

power burner: A burner for which air is supplied at a pressure greater than atmospheric pressure; includes most oil-fired burners and gas burners used as replacements for oil burners.
power draft: See “mechanical draft.”
power-vented: A category III or IV combustion appliance that is constructed and installed with a fan or blower to push all the products of combustion directly to the outdoors through independent sealed vents connected directly to the appliance.

predicted depressurization: Calculated house depressurization after improvements, accounting for estimated change in house tightness and exhaust fan flow.

scope of work: A set of written specifications detailing repairs and improvements to be made to a home; a scope of work may include pre- and post-work performance testing and acceptance criteria.

solar heat gain coefficient (SHGC): The fraction of normal incident solar radiation striking the exterior of a fenestration system that is transmitted as heat to the interior of a building.

spillage: Combustion gases emerging from an appliance or venting system into the combustion appliance zone during burner operation.

U-factor: Coefficient of thermal transmittance (expressed as Btu/h-ft2-oF (W/m2-oC)) of a building envelope component or system, including indoor and outdoor air film transmission coefficients.

unconditioned space: Any enclosed space within a building that is neither directly nor indirectly conditioned.

vent connector: The pipe that connects a combustion appliance to a vent or chimney.
venting system: A passageway from a combustion appliance to the outdoors through which combustion gases pass.

4. General requirements

4.1. **Personnel requirements**. The home performance auditor shall be certified as demonstrating the knowledge and skills required to complete all tasks in this standard (see Annex G).

4.2. **Worker safety requirements**. The home performance auditor shall comply with all applicable OSHA regulations.

4.3. **Customer interview**. The home performance auditor shall conduct an initial interview with the owner or tenant by telephone or in person and shall, at a minimum, collect the information outlined in Annex A.

4.4. **Utility bill review and analysis**. If fuel consumption history is available, the home performance auditor shall estimate annual average cooling, heating,and base load components of fossil and electricity energy use.

5. On-site inspection and data collection requirements

5.1. **Initial Survey**. In a previously or presently occupied home, the home performance auditor shall conduct a survey inspection with the customer to elicit additional issues or concerns. The inspection and data collection shall follow the specifications of Annex B.

5.2. **Data collection for home energy rating.** The home performance auditor shall inspect the home and collect the information required to conduct a home energy rating in accordance with Chapter 3 and Appendix A of the RESNET Mortgage Industry National Home Energy Rating Systems Standards.

5.3. **Building enclosure air-tightness test.** Conduct an air-tightness test.

5.3.1. Air-tightness testing shall be conducted in accordance with ASHRAE Standard 119 RA-2004, Section 5.1. However, the building may be tested at a single pressure differential of 50 Pa, and shall be prepared for testing in accordance with the requirements of the RESNET Mortgage Industry National Home Energy Rating System Standards, Appendix A, in the section titled “Rated Feature – Blower door test”.

Exception. When there is evidence of peeling or damaged lead paint or friable asbestos material that may be disturbed by conducting the test, the test shall not be required. Refer to OSHA 29 CFR 1926.62, and 29 CFR 1926.1101. Untested default values may be used as required for the enclosure air tightness.

5.3.2. During the initial pressurization or depressurization test, the home performance auditor shall determine major leakage areas in the living area. The auditor shall use neutral buoyancy smoke, infrared camera, or other such device to aid in identifying air leak sites and misalignments between the air pressure boundary and the intended thermal boundary. When possible, the customer should accompany the home performance auditor.

5.3.3. Record presence of observed air leaks including but not limited to: window trim, baseboards, upper trim, cabinets, dropped soffits, pocket doors, recessed lighting, duct chases/plenums, band joists; transitions between porch and roof exterior walls, fireplaces, cantilevered floors; in walls or ceilings between the conditioned space and an attached garage.

5.4. **Inspection of mechanical systems**

5.4.1. **Heating and cooling systems**

a. Review maintenance record; record frequency of tune-ups and repairs, as available.
b. In the case of a high-efficiency unit with condensate line, check the drain line for signs of blockage and leaks; record results. Notice if condensate line drains to proper location.
d. Record interference with outdoor unit airflow attributable to proximity of outdoor coil to deck, cantilever, or plantings or heat transfer inefficiencies due to clogging of outdoor coil with debris.
e. For heat pumps, evaluate electric resistance heater sequence of operation to ensure operation only under required conditions (room temperature difference and/or emergency heat setting).

5.4.2. **Distribution system(s)**

5.4.2.1. **Air handlers and coils**

a. Record condition of blower and coil, if accessible, and any need for cleaning.
b. Inspect air filter(s) and check with customer on frequency of change-outs.
c. Record presence of secondary overflow pans; verify presence of condensate drain line or float disconnect switch.

5.4.2.2. **Ductwork**

a. Inspect duct system to extent possible; record insulation R-values, visually detected duct leaks, disconnects, collapsed or kinked ducts, signs of moisture presence and damage, and other sub-standard conditions.
b. Record presence of permanently installed humidifier, along with evidence or reports of its operation, clogging/scaling, or evidence of mold growth in unit.

5.4.2.3. **Duct leakage test.** Conduct a duct leakage test. Duct system leakage shall be measured in accordance with the RESNET Residential Mortgage Industry National Home Energy Rating System Standards.

5.4.2.3.1. **Exception 1:** in an existing home, a duct test need not be conducted when a duct system meets all of the following conditions:

i. The system air handler and a minimum of 75% of the surface area of connecting ductwork are located inside conditioned space.

ii. A "pressure pan" test is conducted as follows: During a blower door pressurization or depressurization test, the blower door is set to maintain a pressure difference of 50 Pa between inside and outside. One at a time, each supply or return register in the system is covered with a "pressure pan" device or airtight membrane, that is sealed or gasketed to the surrounding surface. For each register, the pressure difference between the inside of the building and the space containing the register is measured and recorded.

iii. When measured in this manner, the largest recorded pressure difference at any one register is 3 Pa or less, and the average of the recorded pressure differences at all supply and return registers in the system is 1 Pa or less.

5.4.2.3.2. **Exception 2:** When there is evidence of peeling or damaged lead paint or friable asbestos material that might be disturbed by conducting the test, the test shall not be required. Refer to OSHA 29 CFR 1926.62 and 29 CFR 1926.1101. Unused default values shall be used as required for the duct air tightness.

5.4.2.4. **Boiler system, hot water pipes, steam pipes, and baseboard radiators**

a. Record insulation levels on hot water and steam distribution pipes and note opportunities for pipe insulation, particularly on long pipe runs.
b. Record condition of hydronic baseboards or convectors, positioning of covers, and presence of dust, webs, or other material on fins.
c. Note if steam radiators are pitched properly to drain condensate.
d. Record signs of water leakage from boiler vessel or piping.

5.4.2.5. **Water heater**

a. Record approximate age and condition of water heater(s).
b. Record temperature setting on water heater(s).
c. Record signs of leakage from water heater(s) .

d. Record opportunities for efficiency improvement to water heater(s) and hot water pipes (presence or absence of insulation, thermosiphon loop, and feasibility of retrofitting insulation on tank and/or pipes).

5.4.2.6. **Mechanical ventilation**

a. Record presence of local exhaust venting system in bathrooms and kitchen; as applicable, record duct type and approximate length and location of termination (recirculating, indoors, outdoors, or to attic, garage, crawl space, and so forth).
b. If garage is attached, record presence and operability of exhaust fan in garage.
c. Record presence or absence of powered attic or whole-house exhaust fans.

5.4.3. **Combustion appliance, combustion appliance zone (CAZ), and living space tests and inspections**

5.4.3.1. **General combustion appliance inspections**

a. Record odor or presence of flammable or explosive materials near any combustion source; if found, request immediate relocation of materials or occupants to a safer place.

5.4.3.2. **Water heater inspection**

a. Record evidence of backdraft/flame rollout.
b. Verify that pressure relief valve is present and not obstructed.

5.4.3.3. **Heating system inspection**

a. Record evidence of backdraft/flame rollout.
b. If boiler is present, verify that pressure relief valve is present and not obstructed.

5.4.3.4. **Combustion appliance testing**

a. Combustion appliance testing shall be conducted in the home per Annex D.
b. When the scope of work includes replacement of existing atmospheric-vented equipment with direct–vent or power vented equipment, testing the existing equipment is optional.

6. Software analysis requirements

6.1. **Software.** The home performance auditor shall conduct a Home Energy Rating using software accredited by RESNET for the purpose of conducting comprehensive home energy audits.

6.2. **Billing history**

6.2.1. When billing history for a year or more is available for any fuel, the predicted savings for all proposed measures relating to end-uses using that fuel shall not be greater than 100 percent of all the

annual historical consumption of that fuel. When predicted savings are greater than 60 percent of annual consumption of a fuel, the scope of work shall be accompanied by the following notice: "This proposed package of improvements includes an estimate of fuel savings greater than 60 percent for the following fuel(s): _<*specify: fuel type(s)*>_ . Savings of more than 60 percent of historical consumption is exceptional and would typically indicate a comprehensive set of improvements or a solution to an unusual and specific energy problem."

6.2.2. Predicted savings greater than 100 percent of annual electric consumption may be allowed when on-site power generation is included in the estimate. When predicted savings are greater than 100 percent of electric consumption, the scope of work shall be accompanied by the following notice: "This proposed package of improvements includes on-site power generation in excess of predicted electric consumption. Predicted electric consumption is based on standard operating conditions; actual results may vary due to variations in customer lifestyle and operating conditions."

6.3. **Operating condition exceptions.** The following exceptions to the operating conditions specified in Chapter 3 of the RESNET Mortgage Industry National Home Energy Rating Systems (HERS) Standards shall be used for the purpose of calculating heating and cooling savings estimates for measures in the scope of work, but not for the purpose of calculating the HERS index:

a. Actual thermostat set points observed by the home performance auditor may be used, but automated setback schedules shall be limited to the schedule specified in the RESNET Mortgage Industry National Home Energy Rating Systems Standards, Section 303.5.1.2.
b. Electrical or fossil fuel end-uses that are not covered in the list of Minimum Rated Features may be included in the analysis in accordance with the RESNET Mortgage Industry National Home Energy Rating Systems Standards, Paragraph 303.7.1.5.n.

7. Requirements for development of scope of work

7.1. **Development of scope of work**: The home performance auditor shall develop a scope of work for each building, specifying a set of home performance improvements. The home performance auditor shall review and include, at a minimum, all applicable improvements as required by Annex C.

8. Customer review of HPA findings and documentation

8.1. **In-person interview.** The home performance auditor shall present the customer with an overview of the inspection findings as well as the recommended scope of work.

8.2. **Documentation requirement.** A home performance auditor shall provide the customer with a summary report on the home performance audit in written form (may be electronic). The following elements, at a minimum, shall be included in the summary report:

a. Auditor name, contact information, and certification number
b. Address, city, and state of analyzed home
c. Date of audit
d. Description of existing conditions
e. Pre-improvement home performance assessment findings:
    1. Photographs of existing conditions, where notable
    2. Predominant insulation levels for walls, ceilings, rim joists, floors, and foundation
    3. Type and condition of doors and windows
    4. Enclosure air leakage test results in CFM50.
    5. Identification of major energy-using equipment
    6. Approximate age and condition of HVAC equipment, including model number and capacity (heating, cooling, and ventilation fans), water heating equipment, and exhaust flues for fuel-burning HVAC or water heating equipment
    7. Visual inspection findings for duct system and duct leakage test results.
    8. Results of the combustion appliance tests
    9. Approximate age and condition of appliances
    10. Any signs of moisture damage as recorded in accordance with sections B.4, B.5 and B.6 of this standard
f. Copy of the scope of work in accordance with Section 7 of this standard
g. Copy of HERS rating report

8.3. **Testing Disclosure.** The report generated as a result of combustion appliance testing shall include the following disclosure. The home performance auditor shall review the disclosure notice with the customer, and both the customer and the home performance auditor shall sign the form in duplicate; both shall retain a copy.

8.3.1. The standard disclosure form shall include a disclaimer with the results of any combustion appliance test that declares the limits of applicability, including the following statement:

"The results of the combustion appliance test do not represent the worst-case conditions for depressurization and do not take into account effects of the following:

- Fireplace or woodstove operation

- Exhaust fans rated at less than 150 cubic feet per minute, and appliances such as whole-house vacuum cleaners
- Exhaust effects attributable to combustion gas venting that draws air from the dwelling
- Powered attic fans
- Heat or energy recovery system exhaust on defrost cycle
- Exhaust from negative pressure sources in adjacent dwelling units
- All possible combinations of HVAC fan operation and damper and door operation
- Improper or incomplete installation and maintenance of appliances and venting
- Wind under conditions other than those during the test
- Stack effect variations over time
- Open windows
- Re-entrainment of exhaust gases via another pathway such as a window, air intake, or indirect building air leakage path
- Sustained off-cycle downdrafting in very cold weather, thereby chilling the flue and creating sustained backdraft conditions during operation
- Warm weather with little wind, potentially interfering with a water heater's proper venting against low depressurization levels

In addition, testing furnaces, boilers that do not heat the potable hot water supply, or space heaters, in weather conditions during which they would not normally be operating (i.e., warmer than 60°F) can provide positive spillage results not found when tested in their normal outdoor temperature range.

A Comprehensive Home Energy Audit is neither a building code inspection nor a safety assessment. Acceptance of a Comprehensive Home Energy Audit shall not constitute any warranty, expressed or implied, regarding potential building problems that lie outside the scope of the Home Performance Audit."

Annex A (Normative): Customer Interview

A.1. The home performance auditor shall conduct a customer interview to obtain the following information:

a. Energy consumption history
b. Age of home or year built
c. Number of years occupied by current resident
d. Number of occupants
e. Age of roof
f. General condition; recent and planned remodeling or renovations
g. Use of basement space, if applicable
h. Age and general condition of windows and doors, including evidence of drafts, condensation, or moisture damage
i. Thermostat settings and schedules
j. Comfort complaints such as hot or cold rooms, cold drafts from heat pump registers
k. Building maintenance complaints such as condensation, plumbing or roof leaks, ice dams, or foundation moisture
l. Indoor air quality complaints; occupant allergies or asthma
m. High utility bills; other questions or complaints
n. Presence of swimming pool, including typical open and close dates, daily hours of pump operation, fuel-fired or solar pool heating, and ventilation strategy (if indoors)
o. Number of solid fuel appliances and their use
p. Number of unvented fireplaces or space heaters and their use

Annex B (Normative): Survey inspection and data collection

B.1. The home performance auditor shall conduct an inspection of the home and record any of the following data, which may not be required to complete a Home Energy Rating.

a. **Appliance and lighting inspection.** Record presence and quantity, approximate age, type, and condition of the following:
   - Refrigerator(s), including model number(s) and year(s) of manufacture; if prior to 1993, rated annual consumption if available.
   - Freezer(s)
   - Dishwasher(s)
   - Clothes washer(s)
   - Dehumidifier(s)
   - Room air conditioner(s), whether currently or seasonally installed, including model numbers and EER ratings
   - Showerheads

b. Opportunities to upgrade lighting to ENERGY STAR compact fluorescent (CFL) screw-base lamps or fixtures; estimate of daily operation from customer for any lighting recommended for replacement

c. Number, location, and operability of carbon monoxide alarms in living space

B.2. Building envelope inspection. Record major features of home, including the following:

a. General configuration of home including location of known or identifiable additions, and approximate dates of construction.

b. Roof configuration, attached porch roof, cantilevers, bay windows, dormers, knee walls, crawl spaces, attached or tuck-under garage

c. Opportunities for renewable technology (e.g., access to sunlight on south side)

d. Floor plan, with orientation and exterior dimensions

e. Evidence of high moisture levels in living space, including evidence of moisture deposition or damage under windows, on walls behind furniture, in corners of closets on exterior walls, in other areas of stagnation and thermal bridging, and at flooring adjacent to doors and windows where leakage may occur

f. Condition and durability of siding, trim, fascia, soffit areas, and window and door head jambs, sills and interior trim finish

g. Signs of moisture or ice dam damage on roofing and in walls and soffits

h. Number of exposed (unblocked) attic vents and estimated venting net free area

i. Issues with shading or solar exposure that may affect comfort

j. Surface grades that may direct water to basement, slab, or crawl space

B.3. Attic visual inspection. Record attic conditions, including:

a. Presence of openings in wall top plates, electrical, plumbing, and duct chases; open areas around flues and chimneys and recessed light housings; open framing cavities; dropped soffits; and ceilings.
b. Signs of roof moisture damage (stains, soft or rotted joists, roof deck or rafters, wet or moisture-damaged insulation) from roof leaks or condensation

B.4. Basement visual inspection. Record basement or crawl space conditions, including:

a. Presence of air leakage openings such as around electrical, plumbing, and duct systems; around flue pipes and chimney and accessible sill plate or band joist areas; and around basement windows or exterior doors
b. Presence of vapor barrier over exposed soil; needed repairs
c. Type and condition of slab floor, if present
d. Signs of moisture deposition or damage on basement floors, walls, and sill plate area and around basement windows and bulkhead door

B.5. Enclosure thermal characteristics. Record enclosure thermal characteristics, including:

a. Thermal boundary of home and thermal bridges that compromise integrity of the boundary

Annex C (Normative): Work scope development

C.1. Scope of work requirements

C.1.1. **General.** The requirements for developing the scope of work include:

a. A list of all proposed repairs and home performance improvements
b. Priority listing of proposed efficiency measures as defined by software analysis, sponsored program requirements, or cost-effectiveness screening based on analysis of costs and savings (see Annex H).
c. Estimate of energy savings and an indication of return on investment.
d. A comprehensive home performance package, including (where applicable):
    - Measures that bring ductwork and air handling equipment inside the thermal boundary
    - Upgrades to building enclosure
    - Baseload reductions (such as efficient lighting and appliances)
    - Water-saving measures
    - Cooling load reductions such as shading devices
    - Passive or active solar heating or water heating systems
    - Replacement of equipment with high-efficiency, direct-vent or power-vented replacement(s), required when the total cost of repairs to existing equipment (including necessary combustion appliance testing) exceeds cost to replace or upgrade to a higher performance option
    - Measures that meet or exceed applicable state or local codes set forth by the authority with jurisdiction
    - Compliance with the requirements of the 2006 IECC for thermal and mechanical systems. Upgrading to maximum amount possible when IECC requirements cannot be achieved (for example, when a wall cavity of limited depth is being insulated, the requirement is to fill the cavity; where additional work is specified, such as interior drywall or replacement siding, the addition of rigid insulation to IECC levels shall be included)
e. The following statement: “This comprehensive package is not a list of recommendations that may be chosen individually or in any combination; except as noted, any exclusions or variations from this package may result in compromised home operation including (but not limited to) risk of chimney flue gas spillage or carbon monoxide production.”

C.2. Pre-existing and projected conditions.

C.2.1. Combustion Testing. When conditions that exceed the action levels as specified in section D.4 of this standard have been documented during the home performance audit, or these conditions are likely to be achieved as a consequence of the installation of recommended measures, the scope of work shall include measures to address such conditions.

C.2.2. Building conditions outside the scope of a Comprehensive Home Energy Audit. When building conditions are questionable with regards to moisture, safety, or building codes, the Home Performance Auditor shall recommend that the customer engage the services of a professional with certification or expertise in that area to evaluate risks and make recommendations. Such recommendations shall include (as applicable), but not be limited to the following:

C.2.2.1. **Leaks**. The scope of work shall state that work will not commence before repair of all known or observed roof and plumbing leaks has been accomplished. ,

C.2.2.2. **Crawl space drainage.** Any scope of work for a building with a crawl space foundation(s) with a history of standing water or located in a flood zone shall recommend mitigation of this problem or potential problem.

C.2.2.3. **Electrical components.** The scope of work shall:

a. Recommend an inspection by a licensed electrician or local inspector when potential electrical hazards are found in an area of the home affected by proposed work. The local authority with jurisdiction shall make any determination of hazard and interpret the electrical code.
b. Specify that insulation clearances are to be maintained or fixtures upgraded where there is evidence of recessed lights that are not rated for insulation contact, mounted in a surface where insulation may be applied.
c. Explicitly prohibit the installation of new insulation in hollow spaces of walls, ceilings, or attics where insulation may be in contact with knob and tube wiring per NEC -1987, Section 324.4, and require clearances between insulation and wiring to be maintained in affected areas during installation
   Exceptions:
   1. When the scope of work calls for all wiring in affected areas to be upgraded.
   2. When the authority having jurisdiction allows exceptions to NEC-1987 under specific conditions, Section 324.4, the scope of work shall adhere to those conditions as applicable.

C.3. Moisture control

C.3.1. Window and door flashing

C.3.1.1. Any scope of work that includes installation or replacement of windows or doors shall specify sealant, flashing, drainage, and installation details per ASTM E-2112-07. The scope of work shall specify installation, wherever possible, of sill flashing with end and back dams that drain to the exterior cladding surface under all new windows and doors as well as water-shedding details on the exterior and air-tight foam sealant between new and old frames in replacement windows.

C.3.2. Exterior insulation or cladding

C.3.2.1. Any scope of work that includes exterior rigid insulation or exterior cladding installation shall require the following:

a. Continuous drainage plane or weather-resistant barrier (WRB) behind cladding: may include taped and sealed or flashed rigid insulation, sealed house wrap, or other WRB that is installed shingle-style
b. Window and door flashings at head, jamb, and sill, integrated with WRB to drain to exterior
c. Flashings at roof-to-wall intersections, including step flashings and kick-out flashing consistent with specific climate zone and annual rainfall provided in the EEBA Builder's Guides, where the bottom of any wall terminates at an existing roof; siding edge shall be held 1 inch or more above adjacent roof sections

C.3.3. Crawl space moisture barrier

C.3.3.1. Any scope of work for a building with a crawl space foundation(s) shall include the following:

a. Installation of a minimum 0.006-inch-thick polyethylene or 0.004-inch-thick cross-laminated polyethylene ground moisture barrier
b. Overlapping of edges of moisture barrier by a minimum 12 inches and permanent sealing of all seams and penetrations with acrylic adhesive tape or compatible sealant
c. Lapping moisture barrier up the crawl space perimeter walls a minimum 6 inches
d. Sealing and mechanically fastening or adhering moisture barrier edges to a clean wall surface
e. Documentation of clearance limitations, obstructions, or other conditions that may prevent complete coverage

C.4. Enclosure Air leakage

C.4.1. Sealing. The scope of work shall include sealing the air leakage areas identified during the site inspections under Section 5.3, B.5, B.6, or B.7 of this standard. At a minimum, the scope of work shall specify the following:

a. As a high priority, sealing leaks between the garage and adjacent living space

b. As a priority, sealing leaks or adding new air barrier materials to align the air pressure boundary with insulation
c. As a priority, sealing with blocking or sheathing all openings between framing elements that are open to attic, roof, garage, or crawl space

C.4.2. Air-tightness test. The scope of work shall specify an air-tightness test to be conducted under the following conditions:

a. After work is completed when sealing a new dwelling to a specified level or threshold
b. After work is completed when air sealing a building enclosure or installing closed-cavity insulation
c. After work is completed when sealing a duct system with at least 15 percent of the ducts outside conditioned space, when sealing an air handler located outside conditioned space

C.4.2.1. Air-tightness testing shall be conducted in accordance with section 5.3.1 of this standard.

C.5. Ducts

C.5.1. Duct sealing. The scope of work shall include the sealing of duct systems and air handlers located in attics, garages, and unconditioned crawl spaces identified during the site inspections under 5.4.2.2. or 5.4.2.4 of this standard. At a minimum, the scope of work shall specify the following:

a. As a high priority, sealing of return duct and air handler leaks in attached garage
b. Relocation of air handler or return ductwork when either is located in a garage or creation of an air-tight enclosure to isolate air handler or return ductwork from the garage.

C.5.2. Duct leakage test. The scope of work shall specify that a duct leakage test be conducted under the following conditions:

a. After completion of work when sealing ducts to a specified level or threshold in a new dwelling
b. Both before and after completion of work when sealing a duct system or air handler located outside conditioned space or where significant duct modifications have been completed within conditioned space

C.5.2.1. Duct leakage testing shall be conducted in accordance with the procedures in section 5.4.2.4 of this standard.

C.5.3. Duct repairs.

C.5.3.1. The scope of work shall call for the repair of crushed, poorly fastened, restricted, or poorly supported ducts as well as for any duct system modifications to improve air flow before duct sealing or duct insulation.

C.5.3.2. An air handler air-flow test shall be conducted on air conditioners and heat pumps in accordance with ASHRAE 152-2004, Annex A, using either the "duct-pressurization and flow measurement device" (plenum pressure-matching method) or an "air-handler flow plate device." The air handler air-flow test shall be conducted at the higher of heating or cooling fan speed, under the following conditions:

a. Before and after completion of work, when sealing a duct system or air handler located outside conditioned space is specified in the scope of work
b. Where duct modifications within conditioned space are specified in the scope of work
c. Note: An air-flow test conducted during the home performance audit shall qualify as a specified "before work" air flow test in the scope of work.

C.5.3.3. When the scope of work includes duct sealing or duct system modification in a home where returns are centrally located, the scope of work shall also include the following provisions:

a. The work scope shall include measures to limit pressure differentials across closed doors during air handler operation to 2.5 Pascals or less, by providing ducts or other air transfer pathways between closed room(s) and the main body of the house containing the return(s).
b. The work scope shall include testing or inspection to confirm that pressure differentials across closed doors are no more than 2.5 Pascals unless return transfer air mechanisms are provided according to the following:
    1. Transfer duct(s) at least equal in cross-section area to the supply duct(s), along with door(s) undercut at least 1 inch and unrestricted, or
    2. Transfer grille(s) that provide 0.5 square inch of grille area for each design CFM of supply air flow, with the door(s) undercut at least 1 inch and unrestricted.

    Note: bathrooms, closets, storage rooms, and laundry rooms are exempt from these requirements, except that all supply air provided to a suite containing these rooms shall be included in testing or calculation of the return air transfer from the suite.

C.5.3.4. When the scope of work includes either complete duct replacement combined with attic insulation and sealing, or roof replacement, the scope of work shall also include the option to bring the new duct system and air handling equipment inside the conditioned space, or to extend the conditioned space to include the duct system.

C.5.3.5. The scope of work shall also include:

a. Insulation of duct system components per the IECC requirement when the scope of work includes installation of new duct systems or system components
b. Duct air sealing shall follow any installation or repair
c. Duct insulation, when specified, shall follow any duct air sealing

C.6. Combustion appliances

C.6.1. Combustion appliance testing. The scope of work shall include post-work combustion appliance testing per Annex D of this standard. Post-work tests shall be specified per the home's proposed condition at completion of work and shall specify acceptance criteria for post-work test results.

C.6.2. Gas leaks. The scope of work shall include repair of gas leak(s) detected during the gas leak test (Section E.2 of this standard), and replacement of any worn, damaged, or aged flex connectors observed during the gas leak test Section E.2 of this standard).

C.6.3. Oven CO emission levels. The scope of work shall call for repair or replacement of any oven found to be producing carbon monoxide, as follows:

a. When the measured oven CO is above 100 ppm as-measured, or 400 air-free, but below the limits specified in in Annex D, Table D.4.2, the scope of work shall call for both installation of a minimum of one CO alarm compliant with UL 2034, IAS 6-96, or CSA 6.19-01, per manufacturer's instructions, in a common area on the same floor level as the kitchen; and a service call ("clean and tune") to improve burner operation.
b. When the measured oven CO is above the limits specified in Annex D, Table D.4.2, the scope of work shall call for service to reduce CO levels as low as possible, and in no case over 800 ppm air-free. The scope of work shall call for installation of one or more CO alarm(s) per (a) above when the measured CO after service remains above 100 ppm as-measured or 400 air-free.
c. In any case, replacement of the equipment may be specified in the scope of work, provided that it also calls for post-installation testing in accordance with section E.4 of this standard, and compliance with (a) or (b) above.

C.6.4. Spillage. The scope of work shall specify measures to reduce spillage, when measured in excess of limits specified in the CAZ test/spillage test, as follows:

a. Reduce depressurization when appliance spillage exceeds the time limit only during depressurization conditions (Section E.6.2.3 of this standard); or
b. Correct venting system deficiencies when spillage exceeds the time limit under non-depressurization conditions (Section E.6.2.4 or E.6.2.5 of this standard)

C.6.5. CAZ depressurization. When CAZ depressurization is measured in excess of the limits in Table D.4.1, the scope of work shall call for repairs) by replacement of all affected equipment by new direct-vent or power-vented appliances, or by any combination of the following:

a. Pressure balancing of HVAC air handling equipment, rooms, and ducts
b. Sealing ducts
c. Replacing large intermittent fans with smaller continuous duty-rated fans
d. Isolating the appliance zone from pressure effects by sealing building elements or adding combustion air or exhaust appliance makeup air
e. Replacing subject appliance(s) with appliance(s) with higher depressurization limits than those measured
f. Equipping water heaters with a spill switch such that the gas valve closes whenever sustained spillage occurs; the spill switch shall:
    1. Include a temperature sensor at draft control or diverter
    2. Activate between 120 and 185°F
    3. De-energize the appliance burner control within 5 minutes
    4. Include an automatic or manual reset
    5. Come with user instructions
g. Specifying that any atmospheric-vented water heater that is installed in a CAZ subject to less than 5 Pascals of depressurization during the worst-case CAZ test and that does not spill beyond the limits specified in the CAZ test/spillage (E.6.3.3) must be equipped with a spill alarm with the following properties:
    1. Two or more temperature sensors at draft diverter
    2. Capable of activation between 120 and 185°F
    3. Capable of activation after an initial time delay for alarm, with automatic reset for 5 minutes
    4. Capable of audible notification at 90dBA or greater, with reset
    5. Designed with user test function
    6. Supplied with user instructions

C.6.6. Isolated zones When combustion equipment is already in place or is specified to be installed in a proposed or existing isolated zone, the scope of work shall call for the following:

a. Use of duct mastic for air and duct sealing of all return platform, cabinet, filter slot, and plenum leaks from air handlers or return ductwork in the isolated zone; metal tape is permissible only on cabinet access and service openings
b. Removal of obstructions from existing outside air openings to meet NFPA 54-2006

c. Sealing air leaks in walls, ceiling and/or floors separating the isolated zone from conditioned space, consistent with section E.7.2.1
d. Provision of additional outside air opening area when:
    1. Isolated zone shows a pressure change greater than 5 Pascals during the blower door test; or
    2. Isolated zone shows depressurization greater than 2 Pascals during HVAC operation
e. Combustion air openings equipped with a motorized damper(s) interlocked with all combustion appliances in the space, such that the gas valve opens only when the damper is open
f. Post-work test to confirm that limits in Table D.4.4 are not exceeded

C.6.7. Venting system. The scope of work shall specify repair or replacement of the venting system(s) per Section E.5 of this standard when the results of the venting system inspection (Section E.5) show deficiencies that could cause an unsafe condition.

C.6.7.1. **Exception:** when the scope of work specifies that all appliances connected to subject venting system are to be replaced, such that the venting system is no longer used.

C.7. Mechanical heating, ventilating, and cooling systems

C.7.1. Replacement heating or cooling equipment. When replacement systems are called for, the scope of work shall specify the sizing of replacement systems in accordance with ACCA Manual J: *Residential Load Calculation,* and *Manual S: Residential Equipment Selection*, using the following criteria:
a. Indoor design temperatures of 75°F and 50 to 55 percent relative humidity (cooling), and 70°F (heating)
b. 99 percent (cooling) and 1 percent (heating) outdoor design temperatures for the home's location or most representative city for which design temperature data are available
c. Calculations that account for any measures specified in the scope of work, such as air sealing, duct sealing, window shading, or other load reductions, that reduce heating or cooling loads

C.7.2. Vapor-cycle refrigerant-based equipment. Cooling or heat pump replacement (when specified) shall include:
a. Replacement of inside coil with a new, acceptable match to the outside coil as listed in the version of the ARI *Directory of Certified Product Performance* that is current at the time of the home performance audit, or confirmation of the existing inside coil as an acceptable match per manufacturer's instructions, including presence of TXV (thermal expansion valve) if required
b. Confirmation of acceptable refrigerant charge and air flow per manufacturer's instructions

c. A "clean and tune," including a heat exchanger inspection when an existing gas furnace is to remain in operation
d. For heat pumps, installation of electric resistance lock-out control that activates when outside temperature exceeds 35F (with exception during emergency heat and defrost modes), and test to confirm proper sequence of operation
e. For heat pumps, information provided to customer about indoor thermostat operation to limit electric resistance heating usage after thermostat set-back.

C.7.3. Ventilation system. The scope of work shall include recommendations for either installation of continuous mechanical ventilation and local exhaust ventilation, or upgrades to existing equipment, in accordance with ASHRAE 62.2-2007, Sections 4 and 5.

a. When a blower door test indicates that post-work air leakage is likely to exceed the default infiltration rate specified in ASHRAE 62.2, Section 4.1.3, "Infiltration Credit," the design ventilation system air flow may be reduced per that ASHRAE standard, provided that air-flow rates are adjusted according to the post-work enclosure leakage rate; such adjustment shall not be used for proposed new homes.
b. Mechanical ventilation systems need not be recommended for a home exceeding the leakage rates shown in Annex F, provided that the home meets the conditions shown in Table F.1.
c. The scope of work shall not call for an exhaust-only mechanical ventilation if existing or predicted CAZ depressurization is at or exceeds the limits shown in Table D.4.1 of this standard, for appliances that are to remain in place after completion of the work.
d. Predicted CAZ depressurization resulting from sealing of the building enclosure shall be estimated based on predicted post-work enclosure leakage and expected total post-work exhaust fan flow, per the following equation:

Predicted depressurization (Pa) = 50 x (post-work sum of rated CFM of exhaust appliances/predicted post-work house CFM 50)^1.54, where the rated CFM of exhaust appliances includes all exhaust fans or appliances listed in Section E.6.3.2.1 of this standard that are expected to be operable after completion of work.

C.8. Unvented combustion appliances. When the home has one or more decorative gas logs, as defined in Section K.1.11 of NFPA 54-2006, or any other unvented combustion appliance other than a gas oven or range, the scope of work:

a. Shall not specify enclosure air sealing or duct air sealing. For climate zones 1 through 3 as specified in 2006 IECC, duct sealing outside the air and thermal boundary may be permitted.

b. Shall specify a CO alarm that is labeled as compliant with UL 2034, IAS 6-96, or CSA 6.19-01 for each habitable space that contains an unvented combustion appliance.

C.9. Dust and lead. The scope of work shall specify that contractors adhere to the Toxic Substance Control Act (TSCA) amended by Title X, EPA 40 CFR Rules, and lead-safe practices in any home constructed before 1978 where pre-existing paint finishes or dust may be disturbed as part of the work. Such compliance is not required when the owner has documentation from a certified inspector or risk assessor that the house is free of lead-based paint or has undergone lead abatement in conformance with regulations.

C.10. Carbon monoxide alarm. The scope of work shall specify a minimum of one CO alarm that is labeled as compliant with UL 2034, IAS 6-96, or CSA 6.19-01, to be installed per manufacturer's recommendations in the hallway(s) outside the bedroom area at each floor level.

C.11. Verification. The scope of work shall specify verification of installed work, including all required performance testing and combustion appliance testing, and a confirmed HERS rating per the RESNET Mortgage Industry National Home Energy Rating Systems Standards.

Annex D (Normative): Combustion appliance testing

D.1. Combustion appliance testing. Combustion appliance testing shall be conducted as part of every home performance audit per these requirements and the procedures described in Annex B. Modern direct-vent and power-vented equipment must undergo limited testing; equipment isolated from house pressure effects must undergo a moderate level of testing; and natural-draft equipment that takes combustion and dilution air from inside the home requires detailed testing.

D.1.1. Where recommendations are made as part of a home performance audit for a new home, combustion appliance testing shall be conducted upon completion of the work.

D.1.2. Any scope of work presented to the building owner or occupant shall specify combustion appliance testing as required both before and after completion of work. Testing completed as part of the home performance audit qualifies as required pre-work testing.

D.1.3. Some test procedures are required on all homes per Annex E, Section E.2; other procedures vary depending on specified conditions as outlined in Section E.3.

D.2. Required combustion appliance tests. The following test procedures are required on all homes as applicable:

a. A gas leak test per Annex E, Section E.2
b. A CO test on all combustion appliances per Annex E, Section E.3
c. An oven test (if oven is present) per Annex E, Section E.4
d. A venting system inspection per Annex E, Section E.5
e. A combustion appliance zone (CAZ) test per Annex E, Section E.6
f. As required, an isolated zone test per Annex E, Section E.7

D.3. Appliance conditions and additional required tests. Specified conditions may apply to the home as-is during the test or to the as-proposed home based on the scope of work.

D.3.1. Required tests for direct-vent or power-vented appliances include a visual confirmation that the venting system is connected, that all joints are connected from the appliance to the outdoors, and that the vent is functioning.

D.3.2. Atmospheric-vented appliances in an isolated zone. **Important Note:** Use of any combustion air from indoors to meet combustion air requirements disqualifies an appliance from this designation. Required tests include the following:

a. Visual inspection of venting system per Annex E, Section E.5
b. Confirmation of decoupling of isolated CAZ from house zone per isolated zone test procedure (Section E.7), including isolation of

CAZ from HVAC pressures; isolation from house confirmed with blower door; and spillage test under non-depressurization conditions

D.3.3. Atmospheric-vented appliances. Any atmospheric-vented appliance located within the home that does not meet the requirements in Section D.3.2 of this standard shall require the following tests:

a. Venting inspection per Annex E, Section E.5
b. CAZ depressurization and spillage test per Annex E, Section E.6

D.4. Action levels. The home performance auditor shall include in each recommendation or scope of work specific action to be taken per Annex C of this standard, when certain limits are exceeded. These limits include the CAZ depressurization limits shown in Table D.4.1, sustained vent gas spillage greater than 5 minutes, appliance CO levels in excess of those shown in Table D.4.2, CAZ or indoor CO levels in excess of those shown in Table D.4.3, or a gas leak as determined by Annex E, Section E.2.

D.4.1. Air free measurement of CO, when available, shall take precedence over as-measured.

Table D.4.1 Combustion Zone Depressurization Limits

Appliance type	Depressurization Limit Pascals (IWC)
Direct-vent or power-vented	50 (0.20)
Pellet stoves with exhaust fans and sealed vents	15 (0.06)
Atmospherically vented oil and gas system (except water heater); oil power burner; fan-assisted or induced-draft gas; solid-fuel–burning appliance other than pellet stoves with exhaust fans and sealed vents	5 (0.02)
Atmospherically vented water heater	2 (0.008)

Table D.4.2 Appliance CO Limits, Maximum

Appliance Type	As-Measured	Air-Free
Furnace, boiler, water heater, vented space heater other than solid-fuel–burning	100 ppm *	400 ppm
Oven	200 ppm	800 ppm

* Or original equipment per manufacturer's recommended level if specified.

Table D.4.3 Indoor Air CO limits

NIOSH Personal exposure limit (time-weighted average)	8 hours	35 ppm
NIOSH Personal exposure limit (ceiling)	15 minutes	200 ppm

Table D.4.4 Isolated Combustion Appliance Zone Pressure Limits

Maximum zone pressure change during blower door test @50 Pascals	5 Pa
Maximum change in depressurization during HVAC operation	2 Pa

Annex E (Normative): Combustion appliance test procedures

E.1. Summary of Procedures. The following section includes a set of limited screening test procedures for combustion appliances for the purpose of determining certain unsafe or potentially unsafe conditions and to aid in the development of a scope of work to mitigate or correct such conditions. Tests recommended during installation or periodic maintenance are beyond the scope of the procedures. Included are checks for gas leaks, carbon monoxide, the combustion venting system, flue gas spillage, combustion appliance zone depressurization, and combustion appliance zone isolation.

E.2. Gas leak test

E.2.1. Equipment requirements

a. Electronic combustible gas detector sensitive to 20 ppm
b. Bubble-forming, non-corrosive leak detection fluid

E.2.2. Test procedure. The gas leak test shall be conducted on all accessible natural or liquefied petroleum (LP) gas piping.

E.2.2.1. Using electronic combustible gas detector, inspect all gas fittings and joints in the gas supply lines as well as gas piping and fittings within appliances; confirm potential leaks with leak detection fluid.

E.2.2.2. Inspect all flexible gas lines for kinking, corrosion, soldered joints or connections, or visible wear; inspect and identify for replacement any flexible connectors with a manufacturing date stamp of 1973 or before.

E.2.2.3. Where strong odor or other evidence indicates a major gas leak with gas buildup inside the building, move occupants outdoors and, from outside the building, notify fire department, gas company, or fuel supplier; prevent any switch operation (on or off) or use of other ignition source.

E.3. Carbon monoxide (CO) test

E.3.1. Preparation and equipment

E.3.1.1. Baseline measurement. Before conducting any CO testing, take an outdoor air sample, note results, and make equipment adjustments per manufacturer's instructions.

E.3.1.2. Equipment requirements. Use a test instrument designed to measure CO, with specifications that meet or exceed the following:

a. Range of 0 to 2,000 ppm
b. Resolution of 1 ppm
c. Accuracy ± 5 percent of reading or 20 ppm, whichever is greater
d. Response time of 90 percent of final value within 40 seconds

e. **Note**: Air-free measurements require equipment capable of multiple-gas sampling, including CO and oxygen, plus calculation of air-free value.

E.3.1.3. Calibration: CO detector shall be calibrated annually per manufacturer's instructions.

E.3.2. Indoor air CO test

E.3.2.1. The indoor CO test shall be conducted during initial entry to the building and during the appliance CO, CAZ, and oven tests. Periodically monitor interior CO levels near the auditor conducting the test, but not inside or immediately adjacent to the appliance when combustion appliance(s) are in operation.

E.3.2.2. If the measured indoor CO level rises above 35 ppm, turn off the appliance and ventilate the space.

E.3.2.3. If the measured indoor CO level rises above 200 ppm, evacuate the affected part(s) of the building; re-entry is permissible once indoor CO levels fall below 35 ppm.

E.3.2.4. Confirm that an attached garage or other external source is not the source of indoor CO.

E.3.2.5. If indoor CO levels exceed 35 ppm during testing under non-depressurization conditions (see Annex E, Section E.6.2.4) and the appliance is confirmed to be operating above the limits listed in Annex D, Table D.4.2, disable the appliance and inform the customer that the appliance must be repaired before further operation.

E.3.3. Appliance CO emissions test

E.3.3.1. Combustion product samples shall be taken only long enough for the measurement device to stabilize and complete its sample period without going over-range or loading with moisture.

E.3.3.2. **Atmospheric-vented appliance**. In any atmospheric-vented appliance regardless of location (see Annex D, Sections D.3.2 and D.3.3), undiluted combustion gases (before the draft diverter or draft regulator) shall be sampled for appliance CO emissions, generally during the CAZ test (section E.6.2), with the results recorded. Flue gas samples shall be taken at the outlet of each burner section in the appliance once the appliance has operated long enough to reach steady state (but never less than 5 minutes), and while the burner is firing continuously (except as specified in E.3.3.2.1).

E.3.3.2.1. To measure CO emissions in a fan-assisted appliance with no draft diverter or draft regulator, appliance CO emissions shall be measured inside the vent termination, with the results recorded. If the vent termination is not

accessible, the vent connector may be drilled to take the sample and then plugged after the test.

E.3.3.2.2. For atmospheric-vented appliances (Annex D, Section D.3.2 or D.3.3), flue gas samples for CO measurement shall be taken during the CAZ test procedure (Annex E, Sections E.6.2.3.4, E.6.2.4.2, and E.6.2.5.1 or E.7.2.3.8 as applicable).

E.3.3.3. **Direct- or power-vented appliance**. For any direct-vent or power-vented appliance (Annex D, Section D.3.1), appliance CO emissions shall be measured inside the vent termination, with the results recorded. Equipment shall be run for 5 minutes before taking vent gas samples to allow for warm-up to steady state.

E.4. Oven CO test. The oven test shall be conducted on every operable gas oven/range within a dwelling during a home performance audit.

E.4.1. Preparation and equipment. Same as in Annex E, Section E.3.1.

E.4.2. **Test procedure**

E.4.2.1. Remove any items, including aluminum foil, in or on oven components. Open a window or door or operate the kitchen exhaust fan if the fan terminates outdoors.

E.4.2.2. Ensure that self-cleaning features are not activated. Set oven to the highest normal temperature setting. Turn on oven, close oven door, and begin monitoring CO in the room. Continue to check room CO between oven measurements in the following step.

E.4.2.3. Measure CO concentration inside the oven flue or vent. Samples shall be taken while burner is firing continuously. If, after 5 minutes of operation, the CO levels are higher than 100 ppm (as measured) or 400 ppm (air-free), repeat sampling at 1-minute intervals until subsequent CO measurements stop falling, or burner shuts off. Record lowest value of CO in ppm and shut off oven.

E.5. Venting system inspection

E.5.1. Visually inspect the venting system for proper size and angle from horizontal; look for blockage, restriction, leakage, corrosion, or other visible deficiencies that could cause an unsafe condition. Visually inspect the vent and, where accessible, the connector attachments.

E.5.2. Compare venting system components to NFPA 54-2006, Chapters 12 and 13; NFPA 31 for oil; and NFPA 211 for solid fuels. Record system component details that do not provide at least 90 percent of the required capacities for attached appliance inputs as listed in vent tables, including additional requirements.

E.6. Combustion Appliance Zone (CAZ) test

E.6.1. Preparation and equipment

E.6.1.1. The house shall be set up per the requirements for a blower door test (Section 5.3.1 of this standard). In addition:

a. Set all combustion appliances to the pilot setting or turn off at the thermostat or service disconnect.
b. When mechanical equipment is located in the basement, open the door between the house and basement regardless of thermal boundary location.

E.6.1.2. Equipment requirements include the following:

a. digital pressure gauge capable of measurements to 0.1 Pascal or 0.0004-inches WG at an accuracy of 1 percent of display or twice the resolution, whichever is greater. Digital gauge shall be calibrated or checked for calibration annually per manufacturer's instructions
b. watch or stopwatch
c. smoke generator or small inspection mirror
d. CO analyzer or combustion gas analyzer as per Annex E, Section E.3.1.2.

E.6.2. Combustion appliance zone (CAZ) test procedure

E.6.2.1. Base pressure. Measure and record the pressure of the CAZ with reference to outdoors, called the "base pressure". If the digital pressure gauge has an automatic zeroing or "base" function that adjusts subsequent readings by a measured baseline offset, activate the base function of the gauge now.

E.6.2.2. Establish depressurization conditions

E.6.2.2.1. Turn on the house ventilation system, if any, dryer, kitchen fan, and all exhaust fans rated at 150 CFM or higher. **Exception**: Whole-house ventilation fans intended for summer cooling shall not be operated.

When the test is conducted before installation of all specified exhaust appliances, the blower door shall be used to simulate the airflow (as rated by the Home Ventilation Institute, or HVI) in CFM at 0.25 IWC for the missing appliances. For each clothes dryer (other than a condensing dryer), a default airflow rate of 150 CFM shall be used.

E.6.2.2.2. Turn on the air handler and close each interior door. Check under each door with smoke, pressure gauge, or other indicator to determine the direction of air flow.

E.6.2.2.3. Open all interior doors through which air flows away from the CAZ. Leave all other interior doors closed. Record change in CAZ pressure with reference to the outdoors relative to base CAZ pressure.

E.6.2.2.4. Turn off air handler and note change in pressure of CAZ relative to outdoors as compared to the previous step. If pressure is lower (more negative), leave air handler off. If it does not change or is higher (or less negative), turn air handler back on.

E.6.2.2.5. Measure and record the net change in pressure from CAZ to outdoors as compared to base pressure noted in E.6.2.1. This value shall be considered the depressurization condition for that CAZ for comparison to the values in Annex D, Table D.4.1.

Advisory: Windy conditions can create pressure fluctuations that can make the test less reliable. Accounting for wind fluctuation is beyond the scope of this standard. Consult CGSB 51.71-2005, Appendix B for guidance. For error checking, depressurization conditions may be estimated by using the following calculation:

Estimated net depressurization (Pa) = 50 x (sum of rated CFM of exhaust appliances/house CFM50)^1.54.

Note: This estimate does not include the pressure effects of interior door closure or the combined effects of exhaust and HVAC flows.

E.6.2.3. Spillage and appliance CO measurements

E.6.2.3.1. With the house still under the conditions established in section E.6.2.2, operate the thermostat or control to activate the burner of the appliance with the smallest Btu/hour capacity; note the time or start the stopwatch.

E.6.2.3.2. Monitor CO during the test procedure per the indoor air CO test (Section E.3.2).

E.6.2.3.3. For atmospheric-vented appliances, test for spillage at the draft diverter or draft regulator with smoke or by holding a mirror at the edge of the diverter and looking for fogging. Record any condition of spillage that continues past 5 minutes. **Note:** When testing fan-assisted or induced-draft appliances, check for spillage at draft diverter of common-vented water heater (if present) and at connection to chimney.

E.6.2.3.4. Test the appliance per the appliance CO test in Section E.3.3.

E.6.2.3.5. Repeat the steps in Sections E.6.2.3.1 through E.6.2.3.4 for each separately vented appliance or the smallest within each group of common-vented appliances in order of increasing input capacity. For any appliance that spills for more than 5 minutes of operation under

depressurization conditions, see Section E.6.2.4. If there are common-vented appliances and no spillage, see Section E.6.2.5.

E.6.2.4. Spillage and appliance CO under non-depressurization conditions

E.6.2.4.1. With the appliance still operating, turn off exhaust fans and open interior doors.

E.6.2.4.2. Repeat the spillage and appliance CO test per E.6.2.3; record the results of eliminating the depressurization condition.

E.6.2.4.3. If spillage continues under these conditions, turn off the appliance and recommend that the customer have the venting system and/or appliance repaired before operating it again.

E.6.2.4.4. If spillage continues and CO concentrations are above the limit specified in Annex D, Table D.4.2, an unsafe condition exists. Turn off the appliance and inform the customer that the appliance must be repaired before operating it again. Before leaving the house, the auditor shall either confirm that the customer calls for service or shut off fuel to the appliance. Continue with the remaining steps. If there are common-vented appliances, see Section E.6.2.5.

E.6.2.5. All-appliance spillage and CO for common-vented appliances (input capacity check)

E.6.2.5.1. If no spillage occurred under depressurization conditions (Section E.6.2.3) continue to next step (E 6.2.5.3) and also fire other appliances connected to this vent. Go to E 6.2.5.2 if spillage begins with all appliances operating under depressurization conditions.

E.6.2.5.2. If spillage occurred under depressurization conditions (Section E.6.2.3), leave the first appliance operating, turn off exhaust fans, and open interior doors. **Exception**: When first appliance spills with elevated CO under Section E.6.2.4.4, keep first appliance off and continue test with other appliances connected to this vent.

E.6.2.5.3. Operate the thermostat or control to fire all connected appliances simultaneously and repeat the spillage and appliance CO test per E.6.2.3 on all appliances.

E.7. Isolated zone test. The isolated zone test/inspection is required to confirm eligibility per Annex D, Section D.3.2 as an isolated zone containing combustion equipment. If any of the following requirements is not met, including a basement that cannot be effectively sealed from the house, the

zone shall not be considered isolated. Any atmospheric-vented appliance(s) in that zone shall be tested per Section D.3.3.

E.7.1. Preparation and equipment

E.7.1.1. **House preparation**. The house shall be set up as for a blower door test (Section 5.3.1 of this standard). In addition, set all combustion appliances to the pilot setting or turn off at the thermostat or service disconnect.

E.7.1.2. **Equipment requirements**. Digital pressure gauge capable of measurements to 0.1 Pascal at an accuracy of 1 percent of display or twice the resolution, whichever is greater.

E.7.2. Test procedure

E.7.2.1. **Inspection**. Verify that there are no direct openings between the isolated zone and the home's interior. Direct openings may include, but are not limited to, door undercuts and other leaks in doors and windows, gaps or openings in finish materials, framing openings, ductwork with registers or grilles, transfer grilles, missing or damaged finish materials such as drywall, open chases and building cavities, and unconnected pipes or electrical conduits.

E.7.2.2. **Outdoor combustion air openings**. Measure openings to the exterior to determine compliance with NFPA 54-2006 requirements for combustion air from outdoors per NFPA 54-2006, Sections 9.3.3, 9.3.3.1, and 9.3.3.2; and Annex A, Figures A.9.3.3.(1) (a),(b), and(c). Examples include a single high opening providing 1 square inch net for each 3,000 Btu per hour of combined gas input (recommended for areas that may freeze), or low and high openings to the attic or directly to the outside, providing 1 square inch net for each 4,000 Btu per hour input in each of two vertical openings, or 1 square inch for each 2000Btu per hour input in each of two horizontal openings.

E.7.2.3. **Isolated zone depressurization** This test shall be conducted when the measures in the work scope depend on the existence or creation of an isolated combustion appliance zone.

E.7.2.3.1. Measure base pressure from closed isolated zone to outside per Section E.6.3.1.

E.7.2.3.2. Operate the blower door to change the house pressure by 50 Pascals.

E.7.2.3.3. Measure the change in the isolated zone pressure from the baseline. Maximum change is 5 Pascals during blower door operation at 50 Pascals (Annex D, Table D.4.4).

E.7.2.3.4. Turn off the blower door fan and seal the fan opening.

E.7.2.3.5. Turn on air handler at the thermostat fan switch or by operating the thermostat.

E.7.2.3.6. Measure the change in isolated zone pressure from the baseline after the air handler turns on. Maximum depressurization is 2 Pascals during air handler operation (Annex D, Table D.4.4).

E.7.2.3.7. Operate the thermostat or control to activate the burner of the appliance (if not activated in step E.7.2.3.6); check for spillage and CO at 5 minutes per Sections E.6.2.3.1 through E.6.2.3.4.

Annex F (Normative): Building air leakage values for U.S. and Canadian Cities

F.1 The values shown in Table F.1 are minimum blower-door CFM 50 per square foot of conditioned floor area. An existing home that exceeds this leakage rate may qualify for a ventilation system exemption per Annex C, Section C.7.3.(b).

F.2 **Use of Table F.1**

F.2.1 Starting from the left, find the column that represents the square footage, number of bedrooms, and number of stories in the home.

F.2.2 Note that the square footage range is a minimum; the number of bedrooms is a maximum. If the home does not meet the criteria, move to a column further right.

F.2.3 Note that the number of occupants is assumed to be 1 greater than the number of bedrooms. If the occupancy is known to be higher, use one less than the number of occupants in place of the number of bedrooms in the house.

F.2.4 Choose the city that most closely represents the location of the home.

F.2.5 Multiply the CFM 50 per square foot by the square footage of conditioned space to determine the minimum CFM 50 of the home that is exempt from the mechanical ventilation requirement.

F.3 **Application and limitations**

F.3.1 These values were computed per the methodology in ASHRAE 62.2-2007, Section 4.1.3, "Infiltration Credit"; compare the results to the lesser of the requirements for mechanical ventilation in ASHRAE 62.2, Table 4.1 or Equation 4.1.

F.3.2 Calculations assumed 8-foot-high ceilings. For taller buildings or greater ceiling heights, the required mechanical ventilation will be less; lower limits may be calculated per ASHRAE 62.2, Section 4.1.3. For dwellings with less area or more bedrooms than are shown, the limit shall be calculated per ASHRAE 62.2, Section 4.1.3.

F.3.3 **Note**: All combinations of house size and number of bedrooms shown in the table would result in a requirement of 5 or fewer CFM of mechanical ventilation when applying ASHRAE 62.2, Section 4.1.3. Any increase in square footage beyond the limits shown would quickly reduce the mechanical ventilation requirement to 0.

Table F.1 Minimum CFM 50 per Square Foot of Conditioned Floor Area

		Square Footage (minimum)/Number of Bedrooms (maximum)							
		1 story	2+ story	1 story	2+ story	1 story	2+ story	1 story	2+ story
	State/	1900+/1	900+/1	800+/1	500+/1	500+/1	400+/1	400+/1	300+/1
	Provinc	3300+/2	1600+/2	1400+/2	900+/2	900+/2	600+/2	700+/2	500+/2
City	e		2300+/3	2000+/3	1300+/3	1300+/3	900+/3	900+/3	700+/3

		2900+/4 3600+/5 4300+/6 4900+/7	2500+/4	1600+/4	1600+/4	1100+/4	1200+/4	900+/4
W-factor Multiplier		**1.0**		**1.3**		**1.6**		**1.9**
Adak	AK	0.86		1.12		1.38		1.64
Annette	AK	1.06		1.38		1.70		2.02
Bethel	AK	0.83		1.07		1.32		1.57
Big Delta	AK	1.01		1.31		1.62		1.92
Fairbanks	AK	1.11		1.44		1.78		2.11
Gulkana	AK	1.05		1.37		1.68		2.00
Homer	AK	1.15		1.49		1.84		2.18
Juneau	AK	1.05		1.37		1.68		2.00
King Salmon	AK	0.92		1.19		1.47		1.74
Kodiak	AK	1.08		1.40		1.72		2.04
McGrath	AK	1.11		1.44		1.78		2.11
Summit	AK	0.89		1.16		1.43		1.70
Birmingham	AL	1.45		1.88		2.32		2.75
Mobile	AL	1.32		1.71		2.11		2.50
Calgary	AB	1.06		1.38		1.70		2.02
Edmonton	AB	1.14		1.48		1.82		2.16
Fort Smith	AR	1.32		1.71		2.11		2.50
Little Rock	AR	1.33		1.73		2.13		2.53
Phoenix	AZ	1.47		1.91		2.35		2.79
Prescott	AZ	1.23		1.60		1.98		2.35
Tucson	AZ	1.27		1.65		2.03		2.41
Winslow	AZ	1.22		1.59		1.95		2.32
Yuma	AZ	1.30		1.69		2.08		2.47
Castlegar	BC	1.41		1.83		2.25		2.68
Fort St. John	BC	1.08		1.40		1.72		2.04
Prince Rupert	BC	1.14		1.48		1.82		2.16
Vancouver	BC	1.28		1.67		2.05		2.44
Victoria	BC	1.45		1.88		2.32		2.75
Williams Lake	BC	1.20		1.57		1.93		2.29
Arcata	CA	1.35		1.76		2.16		2.57
Bakersfield	CA	1.47		1.91		2.35		2.79
China Lake	CA	1.49		1.94		2.39		2.84
Dagget	CA	1.11		1.44		1.78		2.11
El Toro	CA	1.75		2.28		2.81		3.33
Fresno	CA	1.45		1.88		2.32		2.75
Long Beach	CA	1.56		2.03		2.50		2.97
Los Angeles	CA	1.52		1.97		2.42		2.88
Mount Shasta	CA	1.28		1.67		2.05		2.44
Point Mugu	CA	1.59		2.06		2.54		3.02
Red Bluff	CA	1.23		1.60		1.98		2.35
Sacramento	CA	1.33		1.73		2.13		2.53
San Diego	CA	1.49		1.94		2.39		2.84
San Francisco	CA	1.09		1.41		1.74		2.07
Santa Maria	CA	1.43		1.86		2.29		2.71
Sunnyvale	CA	1.59		2.06		2.54		3.02
Colorado	CO	1.02		1.33		1.63		1.94

Springs					
Denver	CO	1.15	1.49	1.84	2.18
Eagle	CO	1.25	1.63	2.00	2.38
Grand Junction	CO	1.15	1.49	1.84	2.18
Pueblo	CO	1.18	1.53	1.88	2.24
Hartford	CT	1.16	1.51	1.86	2.21
Washington	DC	1.32	1.71	2.11	2.50
Wilmington	DE	1.19	1.55	1.90	2.26
Apalachicola	FL	1.59	2.06	2.54	3.02
Daytona	FL	1.37	1.78	2.19	2.60
Jacksonville	FL	1.30	1.69	2.08	2.47
Miami	FL	1.45	1.88	2.32	2.75
Orlando	FL	1.37	1.78	2.19	2.60
Tallahassee	FL	1.59	2.06	2.54	3.02
Tampa	FL	1.33	1.73	2.13	2.53
Augusta	GA	1.45	1.88	2.32	2.75
Atlanta	GA	1.33	1.73	2.13	2.53
Savannah	GA	1.33	1.73	2.13	2.53
Hilo	HI	1.67	2.17	2.67	3.17
Honolulu	HI	1.23	1.60	1.98	2.35
Lihue	HI	1.06	1.38	1.70	2.02
Burlington	IA	1.11	1.44	1.78	2.11
Des Moines	IA	1.08	1.40	1.72	2.04
Mason City	IA	0.99	1.29	1.58	1.88
Sioux City	IA	1.01	1.31	1.62	1.92
Boise	ID	1.15	1.49	1.84	2.18
Lewiston	ID	1.41	1.83	2.25	2.68
Pocatello	ID	1.05	1.37	1.68	2.00
Chicago	IL	1.08	1.40	1.72	2.04
Moline	IL	1.16	1.51	1.86	2.21
Springfield	IL	1.08	1.40	1.72	2.04
Evansville	IN	1.32	1.71	2.11	2.50
Fort Wayne	IN	1.09	1.41	1.74	2.07
Indianapolis	IN	1.16	1.51	1.86	2.21
South Bend	IN	1.12	1.46	1.80	2.13
Dodge City	KS	0.90	1.17	1.44	1.71
Goodland	KS	0.92	1.19	1.47	1.74
Topeka	KS	1.15	1.49	1.84	2.18
Lexington	KY	1.25	1.63	2.00	2.38
Baton Rouge	LA	1.43	1.86	2.29	2.71
Lake Charles	LA	1.39	1.81	2.22	2.64
New Orleans	LA	1.41	1.83	2.25	2.68
Shreveport	LA	1.30	1.69	2.08	2.47
Boston	MA	0.93	1.21	1.50	1.78
Churchill	MB	0.81	1.05	1.29	1.53
Thompson	MB	1.09	1.41	1.74	2.07
Baltimore	MD	1.22	1.59	1.95	2.32
Bangor	ME	1.33	1.73	2.13	2.53
Caribou	ME	1.00	1.30	1.60	1.90
Portland	ME	1.10	1.43	1.76	2.09

Alpena	MI	1.22	1.59	1.95	2.32
Detroit	MI	1.09	1.41	1.74	2.07
Flint	MI	1.11	1.44	1.78	2.11
Grand Rapids	MI	1.12	1.46	1.80	2.13
Sault Ste Marie	MI	1.05	1.37	1.68	2.00
Traverse City	MI	1.06	1.38	1.70	2.02
Duluth	MN	1.00	1.30	1.60	1.90
International Falls	MN	1.02	1.33	1.63	1.94
Minneapolis	MN	1.03	1.34	1.65	1.96
Rochester	MN	0.97	1.26	1.55	1.84
Kansas City	MO	1.18	1.53	1.88	2.24
Springfield	MO	1.05	1.37	1.68	2.00
St. Louis	MO	1.15	1.49	1.84	2.18
Jackson	MS	1.47	1.91	2.35	2.79
Meridian	MS	1.61	2.10	2.58	3.06
Billings	MT	0.93	1.21	1.50	1.78
Cut Bank	MT	0.96	1.25	1.54	1.83
Dillon	MT	1.11	1.44	1.78	2.11
Glasgow	MT	0.98	1.27	1.57	1.86
Great Falls	MT	0.95	1.24	1.52	1.81
Helena	MT	1.12	1.46	1.80	2.13
Lewistown	MT	1.11	1.44	1.78	2.11
Missoula	MT	1.27	1.65	2.03	2.41
Saint John	NB	1.05	1.37	1.68	2.00
Asheville	NC	1.45	1.88	2.32	2.75
Cape Hatteras	NC	1.06	1.38	1.70	2.02
Charlotte	NC	1.35	1.76	2.16	2.57
Greensboro	NC	1.39	1.81	2.22	2.64
Raleigh	NC	1.39	1.81	2.22	2.64
Bismarck	ND	1.01	1.31	1.62	1.92
Fargo	ND	0.91	1.18	1.45	1.73
Grand Island	NE	0.94	1.23	1.51	1.79
North Platte	NE	1.05	1.37	1.68	2.00
Omaha	NE	1.15	1.49	1.84	2.18
Scottsbluff	NE	1.01	1.31	1.62	1.92
Stephenville	NF	0.97	1.26	1.55	1.84
Concord	NH	1.32	1.71	2.11	2.50
Lakehurst	NJ	1.43	1.86	2.29	2.71
Albuquerque	NM	1.25	1.63	2.00	2.38
Clayton	NM	0.94	1.23	1.51	1.79
Roswell	MN	1.16	1.51	1.86	2.21
Truth or Conseqence	NM	1.27	1.65	2.03	2.41
Tucumcari	NM	1.15	1.49	1.84	2.18
Shearwater	NS	1.15	1.49	1.84	2.18
Baker Lake	NT	0.80	1.04	1.28	1.52
Fort Smith	NT	1.09	1.41	1.74	2.07
Inuvik	NT	0.99	1.29	1.58	1.88
Elko	NV	1.30	1.69	2.08	2.47
Ely	NV	1.02	1.33	1.63	1.94

Las Vegas	NV	1.23	1.60	1.98	2.35
Lovelock	NV	1.28	1.67	2.05	2.44
Reno	NV	1.33	1.73	2.13	2.53
Tonopah	NV	1.11	1.44	1.78	2.11
Winnemucca	NV	1.19	1.55	1.90	2.26
Yucca Falls	NV	1.30	1.69	2.08	2.47
Buffalo	NY	1.01	1.31	1.62	1.92
Massena	NY	1.11	1.44	1.78	2.11
New York Central Park	NY	1.02	1.33	1.63	1.94
New York LaGuardia Airport	NY	1.01	1.31	1.62	1.92
Rochester	NY	1.09	1.41	1.74	2.07
Syracuse	NY	1.14	1.48	1.82	2.16
Akron	OH	1.10	1.43	1.76	2.09
Cincinnati	OH	1.19	1.55	1.90	2.26
Cleveland	OH	1.04	1.35	1.67	1.98
Columbus	OH	1.16	1.51	1.86	2.21
Dayton	OH	1.16	1.51	1.86	2.21
Toledo	OH	1.11	1.44	1.78	2.11
Youngstown	OH	1.09	1.41	1.74	2.07
Okalahoma City	OK	0.95	1.24	1.52	1.81
Tulsa	OK	1.08	1.40	1.72	2.04
Kapuskasing	ON	1.09	1.41	1.74	2.07
Sault Ste. Marie	ON	1.11	1.44	1.78	2.11
Thunder Bay	ON	1.16	1.51	1.86	2.21
Toronto	ON	1.22	1.59	1.95	2.32
Windsor	ON	1.15	1.49	1.84	2.18
Astoria	OR	1.18	1.53	1.88	2.24
Medford	OR	1.49	1.94	2.39	2.84
North Bend	OR	1.11	1.44	1.78	2.11
Portland	OR	1.32	1.71	2.11	2.50
Redmond	OR	1.25	1.63	2.00	2.38
Salem	OR	1.25	1.63	2.00	2.38
Allentown	PA	1.25	1.63	2.00	2.38
Erie	PA	1.00	1.30	1.60	1.90
Harrisburg	PA	1.32	1.71	2.11	2.50
Philadelphia	PA	1.18	1.53	1.88	2.24
Pittsburgh	PA	1.18	1.53	1.88	2.24
Charlottetown	PE	0.96	1.25	1.54	1.83
Quebec	PQ	1.19	1.55	1.90	2.26
Schefferville	PQ	0.88	1.15	1.42	1.68
Sept Iles	PQ	1.04	1.35	1.67	1.98
Montreal	PQ	1.16	1.51	1.86	2.21
Providence	RI	1.10	1.43	1.76	2.09
Charleston	SC	1.30	1.69	2.08	2.47
Columbia	SC	1.49	1.94	2.39	2.84
Greenville	SC	1.45	1.88	2.32	2.75
Huron	SD	0.92	1.19	1.47	1.74
Pierre	SD	1.00	1.30	1.60	1.90

Sioux Falls	SD	0.95	1.24	1.52	1.81
Regina	SK	0.95	1.24	1.52	1.81
Saskatoon	SK	1.02	1.33	1.63	1.94
Chattanooga	TN	1.56	2.03	2.50	2.97
Knoxville	TN	1.47	1.91	2.35	2.79
Memphis	TN	1.28	1.67	2.05	2.44
Nashville	TN	1.35	1.76	2.16	2.57
Abilene	TX	0.95	1.24	1.52	1.81
Amarillo	TX	0.88	1.14	1.40	1.67
Austin	TX	1.25	1.63	2.00	2.38
Brownsville	TX	1.11	1.44	1.78	2.11
Corpus Christi	TX	1.16	1.51	1.86	2.21
El Paso	TX	1.32	1.71	2.11	2.50
Fort Worth	TX	1.12	1.46	1.80	2.13
Houston	TX	1.23	1.60	1.98	2.35
Kingsville	TX	1.39	1.81	2.22	2.64
Laredo	TX	1.10	1.43	1.76	2.09
Lubbock	TX	1.00	1.30	1.60	1.90
Lufkin	TX	1.56	2.03	2.50	2.97
Midland Odessa	TX	1.04	1.35	1.67	1.98
Port Arthur	TX	1.27	1.65	2.03	2.41
San Angelo	TX	1.19	1.55	1.90	2.26
San Antonio	TX	1.20	1.57	1.93	2.29
Sherman	TX	1.25	1.63	2.00	2.38
Waco	TX	1.09	1.41	1.74	2.07
Wichita Falls	TX	1.01	1.31	1.62	1.92
Cedar City	UT	1.23	1.60	1.98	2.35
Salt Lake City	UT	1.15	1.49	1.84	2.18
Norfolk	VA	1.19	1.55	1.90	2.26
Richmond	VA	1.33	1.73	2.13	2.53
Roanoke	VA	1.35	1.76	2.16	2.57
Burlington	VT	0.91	1.18	1.45	1.73
Olympia	WA	1.30	1.69	2.08	2.47
Seattle	WA	1.18	1.53	1.88	2.24
Spokane	WA	1.18	1.53	1.88	2.24
Yakima	WA	1.23	1.60	1.98	2.35
Eau Claire	WI	1.08	1.40	1.72	2.04
Green Bay	WI	1.06	1.38	1.70	2.02
La Crosse	WI	1.16	1.51	1.86	2.21
Madison	WI	1.10	1.43	1.76	2.09
Milwaukee	WI	1.00	1.30	1.60	1.90
Charleston	WV	1.52	1.97	2.42	2.88
Casper	WY	0.87	1.13	1.39	1.65
Cheyenne	WY	0.93	1.20	1.48	1.76
Rock Springs	WY	1.02	1.33	1.63	1.94
Sheridan	WY	1.20	1.57	1.93	2.29
Whitehorse	YT	1.06	1.38	1.70	2.02

Annex G (Normative): Knowledge Base and Skill Set for the HPA

The following comprise a list of knowledge base and skills necessary for comprehensive home energy audits:

G.1. Building Science Fundamentals

G.1.1. Basic Terms & Definitions (to comprehend and use)

G.1.1.1. Airflow in buildings / ducts: CFM, CFM50, CFM25, ACHnatural, ACH50, FPM

G.1.1.2. Equipment Efficiencies: AFUE, SSE, SEER, EER, HSPF

G.1.1.3. Power and energy: watts, BTU/hr, ton of refrigeration, watt-hours, BTU, therm, decatherm

G.1.1.4. Effective leakage area

G.1.1.5. Area weighted R-Value

G.1.1.6. Baseload / Seasonal energy use

G.1.1.7. Driving forces: Pressure, temperature, moisture differential

G.1.1.8. Thermal resistance / transmittance: R and U Values

G.1.1.9. Latent / Sensible heat: evaporation, condensation / specific heat, heat capacity

G.1.1.10. Duct total equivalent length

G.1.1.11. Dehumidification / Humidification

G.1.1.12. Pressure units: Inches of Water Column (iwc), Pascal (Pa)

G.1.1.13. Natural / mechanical ventilation

G.1.1.14. Net free area

G.1.1.15. Input / output capacity

G.1.1.16. Peak electrical demand

G.1.1.17. Permeability and perm rating

G.1.1.18. Standby loss

G.1.1.19. IAQ (indoor air quality): moisture, CO, dust

G.1.2. Principles of Energy, Air & Moisture

G.1.2.1. Thermodynamics: conduction, convection, radiation, ΔT

G.1.2.2. R-values & U-values

G.1.2.3. UA concepts

G.1.2.4. Parallel paths

G.1.2.5. Film coefficients

G.1.2.6. Buoyancy

G.1.2.7. Forced air flows

G.1.2.8. Solar (absorptance + reflectance + transmittance = 1.0)

G.1.2.9. Far infrared (emittance = absorptance; emittance, reflectance, absorptance, transmittance)

G.1.2.10. Factors that affect insulation performance: density, installation, moisture

G.1.2.11. House pressurization/depressurization by various forces

G.1.2.12. Heat gain / loss: internal, solar, heat transmission, air leakage

G.1.2.13. Power and energy: BTU content of fuels, capacity of combustion appliances and electrical appliances

G.1.2.14. Moisture transport mechanisms: bulk water, air leakage, diffusion, capillary action

G.1.2.15. Dew point

G.1.2.16. Relative humidity

G.1.3. Combustion Science

G.1.3.1. Combustion analysis: oxygen, flue-gas temperature, carbon monoxide

G.1.3.2. Carbon Monoxide (CO) testing of combustion appliances

G.1.3.3. Basics of: Combustion appliance venting, draft, and combustion air

G.1.3.4. Combustion safety issues: Combustion air, draft, worst case / baseline depressurization, spillage, backdrafting, unvented combustion appliances

G.2. Buildings and their Systems (Fundamentals)

G.2.1. Building Components

G.2.1.1. Basic duct configurations and components and associated problems

G.2.1.2. Basic hydronic distribution configurations and components and associated problems

G.2.1.3. Basic structural components of residential construction and potential ramifications on energy use

G.2.1.4. Identifying minimum rated features as defined in the National Home Energy Rating Technical Guidelines:

G.2.1.5. Identify and document the features of the rated home in accordance with the requirements of Section B.5. and Appendix A of the National Home Energy Rating Technical Guidelines.

G.2.1.6. Controls (standard, programmable, multi-zone thermostats)

G.2.1.7. Thermal boundaries and insulation applications

G.2.1.8. Basic electrical components and safety considerations

G.2.1.9. Basic fuel delivery systems and safety considerations

G.2.1.10. Basic bulk water management components (drainage, plumbing, gutters, sumps, etc)

G.2.1.11. Vapor barriers/retarders

G.2.1.12. Radiant barrier principles and installations

G.2.1.13. Understand fenestration types and efficiencies

G.2.1.14. Understand issues involved with basements, crawlspaces, slabs, attics, attached garages, interstitial cavities, and bypasses

G.2.1.15. Understand issues involved with ventilation equipment

G.2.1.16. Understand basic heating / cooling equipment components controls and operation

G.2.1.17. Understand basic DHW equipment components controls and operation

G.2.1.18. Identify common mechanical safety controls

G.2.1.19. Identify insulation types and R-Values

G.2.1.20. Understand various mechanical ventilation equipment and strategies: whole house, local, ERV, HRV, enthalpy, exchange

G.2.1.21. Ventilation exchanger efficiency, fan power and duty cycle characteristics

G.2.2. Conservation Strategies

G.2.2.1. Appropriate insulation applications and installation based on existing conditions

G.2.2.2. Opportunity for ENERGY STAR lighting and appliances

G.2.2.3. Identify duct sealing opportunities and applications

G.2.2.4. Understand importance of air leakage control and remediation procedures including interaction with insulation performance/ improvements

G.2.2.5. Blower door-guided air sealing techniques

G.2.2.6. Water conservation devices and strategies

G.2.2.7. Domestic Hot Water (DHW) conservation strategies

G.2.2.8. Heating & cooling efficiency applications

G.2.2.9. Proper use of modeling to determine heating and cooling equipment sizing and appropriate energy conservation measures (including impacts on energy use and humidity control)

G.2.2.10. Understand the use of utility history analysis in conservation strategies

G.2.2.11. Appropriate applications for sealed crawlspaces basements and attics

G.2.2.12. Appropriate applications for fenestration upgrades including modification or replacement

G.2.3. Comprehensive Building Assessment Process

G.2.3.1. Determine areas of customer complaints/concerns in interview

G.2.3.2. Understand / recognize need for conducting appropriate diagnostic procedures including when to refer to a specialist for further investigation

G.2.3.3. Interaction between mechanical systems, envelope systems and occupant behavior

G.2.4. Design Considerations

G.2.4.1. Appropriate insulation applications based on existing conditions

G.2.4.2. Understand fire codes as necessary to apply home-performance in a code-approved manner.

G.2.4.3. Understand/recognize building locations where opportunities for retrofit materials and processes are needed to correct problems and/or enhance performance

G.2.4.4. Understand climate specific concerns

G.2.4.5. Understand indoor environment considerations for the environmentally sensitive

G.2.4.6. Understand impact of building orientation, landscape drainage, and grading

G.2.4.7. Opportunity potential renewable energy applications: geothermal , photovoltaic, wind

G.2.4.8. Understand impact of shading on heating / cooling loads

G.2.4.9. Awareness for solar gain reduction in cooling climate/solar gain opportunities in heating climates

G.2.4.10. Material and building durability

G.2.4.11. Understand need for modeling various options for heating, cooling and DHW applications, as well as other efficiency upgrades

G.3. Measurement and Verification of Building Performance (Fundamentals)

G.3.1. Applied Diagnostics & Troubleshooting

G.3.1.1. Application of measured air leakage test results

G.3.1.2. Understand building shell/envelope leakage as a function of pressure difference and the size of holes in the air barrier

G.3.1.3. Apply fundamental construction mathematics and unit conversions

G.3.1.4. Calculate building tightness levels (minimum ventilation requirements)

G.3.1.5. Ventilation calculations and strategies

G.3.1.6. Proper methods for identifying / testing fuel leaks

G.3.1.7. Blower door setup, accurate measurement and interpretation of results

G.3.1.8. Duct leakage testing (total leakage and leakage to outside): setup, accurate measurement and interpretation of results

G.3.1.9. Combustion Appliance Zone (CAZ): depressurization, spillage, draft, Carbon Monoxide (ambient and flue)

G.3.1.10. Carbon Monoxide (CO) evaluation: ambient

G.3.1.11. Proper applications and use of temperature measuring devices

G.3.1.12. Pressure pan and room to room pressure diagnostics

G.3.1.13. Pressure differentials and measurement techniques

G.3.1.14. Recognize contributing factors to comfort problems

G.3.1.15. Inspect for areas containing moisture or bulk water in undesirable locations

G.3.1.16. Measures of efficiency

G.3.1.17. Determination of efficiency (nameplate, age-based defaults, etc.)

G.3.1.18. Relative Humidity

G.3.1.19. Understand and inspect for basic electric safety (e.g. frayed wires, open boxes, etc)

G.4. BPI National Standards and Project Specifications

G.4.1. Comprehensive Building Assessment

G.4.1.1. Understand applicability content and intent of BPI National Standards

G.4.1.2. Recognize need for a professional local/state/national codes evaluation

G.4.1.3. Produce a scaled and dimensioned sketch of a home.

G.4.1.4. Be able to specify appropriate materials and processes needed for building performance projects

G.5. Analyzing Building Systems

G.5.1. Comprehensive Building Assessment

G.5.1.1. Recognize need for air sealing measures and their impact on other building systems

G.5.1.2. Recognize need for mechanical equipment improvements

G.5.1.3. Understand blower door use for identifying critical air sealing areas

G.5.1.4. Apply blower door test results in development of improvement strategies

G.5.1.5. Using safety testing results to develop appropriate recommendations

G.5.1.6. Determine appropriate method for assessing wall insulation levels

G.5.1.7. Identification of insulation defects and ability to account for them in energy analysis tool inputs.

G.5.1.8. Equipment control strategies for maximizing occupant comfort and minimizing energy consumption

G.5.2. Appliances and Lighting

G.5.2.1. Understand benefit for ENERGY STAR labeled lights and appliances

G.5.2.2. Understand impact on load associated with lighting and appliance retrofits

G.6. Conduct & Communications

G.6.1. Conservation Strategies

G.6.1.1. Present options for comprehensive conservation strategies that are consistent with sound building science practices

G.6.1.2. Understand the implications of building performance improvements on occupants and other building systems/components

G.6.1.3. Provide appropriate cost benefit analysis guidance

G.6.2. Personal Safety & Work Practices

G.6.2.1. Locations in which to identify indoor air quality issues

G.6.2.2. Material Safety Data Sheets

G.6.2.3. Isolation procedures for pollutants

G.6.2.4. Practice building science within your limits of professional competency

G.6.2.5. Precautions when working around chemical biological and other potential hazards

G.6.2.6. Understand role and responsibilities of the building analyst professional

G.7. Rating Procedure

G.7.1. Understanding construction documents

G.7.1.1. Building drawings

G.7.1.2. Specifications

G.7.2. Field data collection (including photo documentation)

G.7.2.1. Physical measurements

G.7.2.2. Completing scaled sketches

G.7.2.3. Measuring building dimensions

G.7.2.4. Determining building orientations

G.7.2.5. Measuring window overhang lengths and heights

G.7.2.6. Determining roof slopes, gable heights, etc.

G.7.2.7. Calculating gross and net areas and volumes.

G.7.3. Energy feature documentation

G.7.3.1. Energy Analysis (Software) tool data requirements

G.7.3.2. Developing and using field inspection forms

G.7.3.3. Organizing data entry procedures

G.7.4. Characterizing envelope features

G.7.4.1. Determining wall types

G.7.4.2. Determining window and door types and characteristics

G.7.4.3. Determining envelope insulation types, thickness, thermal characteristics and weighted average thermal values

G.7.4.4. Determining duct system characteristics (duct types, insulation value, location with respect to the thermal and air barrier)

G.7.5. Equipment efficiencies determination

G.7.5.1. Nameplate data

G.7.5.2. ARI and GAMA guides

G.7.5.3. Age-based defaults

G.7.5.4. In situ measurements

G.7.6. Performance testing

G.7.6.1. Envelope leakage

G.7.6.2. Air distribution system leakage

G.7.7. Local climate impacts

G.7.7.1. Major US climate zones

G.7.7.2. 97.5% and 2.5% design conditions

G.7.7.3. Cooling and heating design trade-offs

G.7.8. Utility prices

G.7.8.1. Revenue-based pricing

G.7.8.2. Reliable sources

G.7.9. Reports

G.7.9.1. Minimum reporting requirements

G.7.9.2. Improvement analysis

G.7.9.3. Projected and confirmed ratings

G.8. Operating Procedures and Office Administration

G.8.1. National guidelines and standards

G.8.1.1. Accreditation Procedures

G.8.1.2. Technical Guidelines

G.8.1.3. Training & Certification Standards

G.8.2. Understanding the Reference home and rating method

G.8.2.1. Reference Home as defined in B.2 of the National Home Energy Rating Technical Guidelines ("Twin" home concept): "The reference home is the geometric twin of the rated home, configured to a standard set of thermal performance characteristics, from which the energy budget, that is the basis for comparison, is derived."

G.8.2.2. HERS Score computation using the Normalized Modified Loads Rating Method

G.9. Uses of a Rating

G.9.1. Builder assistance

G.9.1.1. Cost effective building design assistance

G.9.1.2. Quality assurance assistance

G.9.1.3. Marketing

G.9.2. Program qualifications

G.9.2.1. EPA Energy Star

G.9.2.2. Utility

G.9.2.3. Other

G.9.3. Financing advantages

G.9.3.1. Energy Efficient Mortgages (EEM)

G.9.3.2. Energy Improvement Mortgages (EIM)

G.9.3.3. Energy Code compliance

G.9.3.4. Added appraisal value

G.9.3.5. Consumer education

G.9.3.6. Understanding real estate, financing and economic terminology

G.9.4. Dealing with clients

G.9.4.1. Understanding the business aspects of being a energy rater

G.9.4.2. Cultivating builder, banker and real estate partners.

G.9.4.3. Knowing who the customer is.

G.9.4.4. Providing excellent service.

G.9.4.5. Ethics and disclosure

Annex H (Informative): Statistically Proven High-impact Treatments

H.1 Where past treatment and utility data are available within program areas, market regions, or for a particular type of housing stock, statistical analysis can provide a powerful tool for guiding recommendations for repairs and treatments. Such data may support lists of recommended measures, be used to qualify results from software analysis, or both, provided that the limitations of applicability of the data to the subject population are respected. For example, housing type, climate, programmatic limitations, availability of billing history for pre-screening, and diagnostics in combination with measure application all influence the effectiveness of measures in a program or population.

H.2. **Example priority list**. The following list is taken from a compilation of results from a large number of weatherization program evaluations in climate zones across the United States:

a. Seal and insulate ducts located in attics, garages, and crawl spaces, or change the thermal boundary to include duct system(s).
b. Fill wall cavities where there is no insulation, or fill cavities in instances of poor insulation (less than 1.5 inch) and where air leaks may be sealed. To reduce leakage at framing connections, install blocking or air barriers at partition wall and floor intersections with exterior walls and at other assembly intersections.
c. Install attic insulation that meets or exceeds code R-values where 3 inches or less of insulation is already in place.
d. Undertake air sealing when the local climate, fuel cost, and construction details make it cost-effective.
e. Install ENERGY STAR windows when existing windows are single-pane, jalousie, or deteriorated.
f. Replace inefficient furnace or boiler in homes with high fuel usage (e.g., gas heat threshold between 1,000 and 1,400 ccf/year) with 92+ AFUE.
g. Engage trained technician for AC tune-up and correct measurement of charge and air flow (hot climates).
h. Repair hot water leaks.
i. Replace old refrigerators, removing or replacing inefficient second refrigerators.
j. Replace lighting with high-efficiency lighting in high-use areas where feasible.

k. Recommend automatic air handler operation if existing fan runs full-time.
l. Recommend on-demand use of 24-hour plug and lighting loads whenever possible (computer, ceiling fan, lighting, and television).

H.3. **Pre-Screening**. High users have the highest savings potential—not only in absolute terms but also in relative terms (percent of usage saved). Cost-effectiveness also improves with higher initial consumption; project costs are higher, but savings increase faster. Obtaining billing history and separating heating, cooling, and base load uses should be a priority for any home performance auditor working with existing homes.

Bibliography

Sources and standards used in preparation of this standard, in addition to the normative references listed in Section 2 of this standard:

ANSI Z223.1-2006, Section 8.1.5.2, and Annex E

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E.3.2.2

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ASHRAE 136