Building Performance Institute, Inc.

BPI Standards

BPI-101

# Home Energy Auditing Standard

**Raising the Bar in Building Performance Contracting**

**May 5, 2010 - Draft**

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[Formulated under the cognizance of the BPI standards Technical Committee.]

# Table of Contents

# Introduction

(Informative)

The Building Performance Institute, Inc. (BPI) publishes standards for the existing residential building retrofit industry. This *Home Energy Auditing Standard* is the basis for BPI's Energy Auditor Certification and provides guidelines for the energy-auditing profession. This standard's goal is to direct the energy auditor to develop a comprehensive list of measures which lead to whole-building, science-based energy improvements to existing low-rise residential buildings (single-family and multifamily). In this standard, these buildings are called "homes." An energy audit is an evaluation of a home's existing energy profile and the potential to improve the home's energy performance, and considers the policies and procedures of applicable residential energy programs.

This standard is not specific regarding energy conservation measures and criteria. The auditor's role may vary depending on the context in which the audit was conducted. The energy auditor may be an independent third party, a sales person working for a contractor, or a weatherization inspector. This standard assumes energy auditors will also follow in good faith their company policy and also conform to the policies of any participating program sponsor or funding source, as applicable, concerning energy-savings estimates and cost-benefit analysis.

Program requirements (including conditions for incentives), laws or regulations, and applicable building codes or ordinances may take precedence over these standards in setting requirements for energy audits, work scopes, and Energy Conservation Measures (ECMs). Consumers and third-party funding sources often require an accounting of ECM costs and savings, energy savings, demand savings, and/or emissions reductions. Additionally, regional climate, housing types, and market conditions vary.

# BPI-101 Home Energy Auditing Standard

## 1. Scope

This standard practice defines the criteria for conducting a building-science-based evaluation of homes (residential low rise buildings) in terms of energy usage, durability, and occupant health/safety and provides a comprehensive scope of work to improve the home. The scope of work shall include a cost-benefit analysis.

## 2. General Energy Audit Requirements

An energy audit shall fulfill the following requirements:

2.1. Include a report, which considers applicable energy programs, incentives, regulations, energy costs, fuel process, and typical local energy-consumption levels.

2.2. Be based on building-science principles and include the use of appropriate equipment in diagnosing opportunities for improving energy efficiency, and minimizing health and safety hazards.

2.3. Include a base load energy use analysis and advice to clients on reduction strategies.

2.4. Produce a work scope that recognizes best-practice installation procedures as well as recommends a comprehensive set of specific energy efficiency and health/safety measures warranted by the site-specific circumstances.

## 3. Health-and-Safety Related Requirements

The energy audit report shall communicate health and safety concerns related to energy systems and proposed retrofit work. The report shall include recommendations to maintain or improve existing levels of health and safety and mitigate identified hazards.

The energy audit shall:

3.1. Not endanger the occupants or the auditor.

3.2. Include an interview of the occupant(s) about their awareness of energy-related home hazards.

3.3. Include a test of all combustion appliances in accordance with Section 7 of this standard.

3.4. Evaluate ventilation requirements in accordance with Section 8 of this standard.

3.5. Identify signs of moisture problems in accordance with Section 9 of this standard.

The energy audit report shall:

3.6. Identify existing hazards and hazards that may develop when the measures are installed and specify preventative measures.

3.7. Inform customers about identified and potential fire, structural, health, and safety hazards related to energy systems and retrofit work.

3.8. Specify in the recommendations that workers do not disturb known or suspected lead, asbestos, or mold, unless the workers are qualified and use appropriate containment, cleaning, and/or abatement procedures.

3.9. Inform customers about potential radon risk. Recommend radon testing in accordance with EPA guidelines, unless a sufficient radon-mitigation system is already in place.

3.10. Specify in the work scope that identified electrical hazards, which may hinder planned ECMs, are mitigated.

3.11. Specify appropriate safe work practices in the work scope.

## 4. Disclosure and Ethics

The energy audit report shall provide clear and accurate information to customers about ECMs, and health-and-safety improvements.

The energy audit report shall:

4.1. Disclose any potential conflict of interest of the auditor.

4.2. Disclose any products and services that the auditor or his/her company provides in addition to energy auditing.

4.3. Communicate as accurately as possible the cost-effectiveness and feasibility of the recommended ECMs, based on modeling, utility-bill history, or typical usage and energy cost for similar homes in the area.

4.4. Communicate the relative importance of each recommended health-and-safety improvement.

4.5. Provide to the customer a list of one or more contractors (BPI-accredited or equivalent), who perform diagnostic testing and retrofit work as applicable based on the work scope. If there is a local energy-efficiency retrofit program, the energy auditor may provide the home owner with program contact information instead of individual contractors.

## 5. Cost-Benefit Analysis

5.1. The audit shall include a comprehensive package of ECMs, using one of the following three methods for cost-benefit analysis:

5.1.1. Computer analysis using software approved by the U.S. Department of Energy (DOE).

5.1.2. Computer analysis, using software that is accredited by BPI, for conducting an analysis of energy savings and developing an appropriate work scope.

5.1.3. A priority list developed using computer analysis of regional housing stock and current energy prices. The priority list shall specify both seasonal and baseload ECMs and identify the type of housing covered by the priority list.

5.2. When energy-consumption records are available, the audit shall include an analysis of energy consumption records (at least 12 months) to justify estimates of energy savings from the installed ECMs.

## 6. Work Scope

The energy audit shall include a work scope detailing proposed ECMs. This work scope shall be based on an evaluation of the whole house according to the requirements of this standard and the objectives of the customer. The work scope shall not be based primarily on a narrow product line, services of a contractor or convenience. The objective of the work scope is to optimize home performance cost-effectively, while maintaining or improving health and safety, and satisfying customer objectives.

The energy audit shall include the following requirements:

6.1. Interview with customers to understand their priorities and goals for home improvements.

6.2. Prioritization of health-and-safety improvements according to their urgency and importance.

6.3. Prioritization of ECMs, building repairs, and renovation according to cost-effectiveness, feasibility, and customer objectives.

6.4. Pre-work and post-work verification (such as diagnostic testing) and should include all measures identified as part of the audit.

## 7. Combustion Appliance Testing

The energy audit shall include inspection of combustion systems for common safety problems that may be related to ECMs. The energy audit report shall specify remediation of conditions as required and shall specify that post-retrofit combustion-appliance testing be conducted.

7.1. Identify and communicate emergency problems — such as a gas leak or a dangerous level of carbon monoxide — clearly and immediately to the customer, landlord, utility representative, and/or the auditor’s supervisor and suggest appropriate solutions.

7.2. Test for gas leakage at connections of natural gas and propane piping systems. The report shall specify repair for leaks and replacement for hazardous or damaged gas connectors.

7.3. Inspect for oil leakage in oil-fired heating and water-heating systems.

7.4. Inspect combustion venting systems for damage, leaks, disconnections, and other safety hazards.

7.5. Include combustion-appliance-zone (CAZ) pressure tests, carbon monoxide (CO) tests, and spillage tests on all combustion appliances venting into atmospheric chimneys, including fan-assisted gas appliances, as follows.

7.5.1. Monitor for ambient CO during combustion testing, and discontinue testing if ambient CO level exceeds 35 parts per million (ppm).

7.5.2. Measure baseline pressure in the CAZ with reference to (WRT) outdoors.

7.5.3. Activate exhaust fans, clothes dryer, and air handler to maximize negative pressure in the CAZ, with the exception of whole-house fans designed for night cooling.

7.5.4. Open or close interior doors as needed to maximize negative pressure in the CAZ.

7.5.5. Measure the change in CAZ pressure WRT outdoors that is induced by exhaust fan, air handler and door position, as compared to the baseline pressure obtained in 7.5.2. If the change in pressure is more than 5 Pa in the negative direction, the audit report shall specify measures to mitigate that induced negative pressure in the CAZ.

7.5.6. Operate open-combustion appliances, beginning with the smallest input, and test for spillage at the draft diverter, barometric draft control, or burner inlet (fan-assisted appliances). If a combustion appliance spills for longer than 1 minute, the audit report shall specify measures to mitigate spillage.

7.5.7. Test for CO in undiluted flue gases of combustion appliances. If CO in undiluted flue gases is more than 100 ppm as measured or 200 ppm air-free measurement, the audit report shall specify service to reduce CO to below these levels (unless CO measurement is within manufacturers' specifications).

7.6. Include a CO test on all sealed-combustion and power-vented appliances (without atmospheric chimneys).

7.7. When cost-effective and feasible, the audit report shall recommend replacing open-combustion equipment with high-efficiency, sealed-combustion equipment or power-vented equipment (or non-combustion equipment, such as a heat pump).

7.7.1. The audit report shall specify CO testing for newly installed sealed-combustion and power-vented appliances.

7.8. Test gas ovens for CO.

7.8.1. If ovens produce more than 200 ppm of CO (or 400 ppm air-free measurement) in undiluted flue gases tested in the oven vent, the audit report shall specify service or replacement.

7.8.2. The audit report shall specify that every kitchen be ventilated as required in Section 8.2.

The energy audit report shall:

7.9. Specify smoke alarms for homes, per local code as a minimum, that don't already have them installed.

7.10. Specify CO monitors/alarms in homes with combustion appliances or attached garages, one per floor level.

7.11. Specify final combustion testing at project completion, to ensure compliance with the above standards.

## 8. Indoor Air Quality and Ventilation

8.1. The energy audit shall strive to maintain or improve indoor air quality. The energy audit report shall specify improvements to reduce pollution sources and to provide adequate ventilation as follows.

8.1.1. Identify sources of indoor air pollution for customers, and recommend the removal of the pollutant or the implementation of the proper control.

8.1.2. Document the flow rate of all exhaust fans and document whether the exhaust fans and clothes dryers vent to outdoors.

8.1.3. With an attached garage, document that an effective air barrier exists or include sealing of air leaks between the garage and house. Also, the energy audit report shall include sealing of air handlers and ducts that are located in the garage.

8.1.4. Document mechanical ventilation requirements using the approach based on the ASHRAE 62.2 - 2007.

~~8.1.4.1. As an alternate, a legacy approach based on ASHRAE 62-1989 is permitted; see Annex A. This alternate is permitted for new work scopes until July 1, 2013.~~

8.1.5. Specify whole-house mechanical ventilation for all homes based on ASHRAE Standard 62.2 – 2007, Section 4, as follows:

8.1.5.1. Nominal fan size to continuously provide airflow in cubic feet per minute (CFM) is based on the number of bedrooms and the conditioned floor area of the home. The fan's CFM shall have been determined by using either the formula or the table that follows. The formula for CFM fan flow is:

**CFM = (0.01 x conditioned floor area) + (7.5 x (number of bedrooms + 1))**

8.1.5.2. The table for CFM fan flow follows:

**Table 1. Accepted Sizing for Continuous Ventilation Fans**

| | Number of Bedrooms | | | | |
|---|---|---|---|---|---|
| **Floor Area (sq ft)** | 0-1 | 2–3 | 4–5 | 6–7 | >7 |
| < 1500 | 30 | 45 | 60 | 75 | 90 |
| 1501–3000 | 45 | 60 | 75 | 90 | 105 |
| 3001–4500 | 60 | 75 | 90 | 105 | 120 |
| 4501–6000 | 75 | 90 | 105 | 120 | 135 |
| 6001–7500 | 90 | 105 | 120 | 135 | 150 |
| > 7500 | 105 | 120 | 135 | 150 | 165 |
| From ASHRAE Standard 62.2-2007, Table 4.1 | | | | | |

8.2. Specify local (spot) ventilation for kitchens and bathrooms according to ASHRAE Standard 62.2 – 2007, Section 5. Use one of the two following options for complying with the kitchen and bathroom ventilation requirements. Both bathroom and kitchen requirements may be met by dedicated exhaust fans and/or a central ventilation system.

8.2.1. The report shall specify that each bathroom receives a minimum of 50 CFM of intermittent exhaust (with appropriate controls), or 20 CFM of continuous exhaust. Also specify that each kitchen receives a minimum of 100 CFM of intermittent exhaust or 5 air changes per hour (ACH) of continuous exhaust based on kitchen volume.

8.2.2. If existing ventilation equipment can’t be used to fulfill 8.2.1, and new equipment isn’t specified, then airflow from the whole-house ventilation system may be increased to compensate, according to ASHRAE 62.2 – 2007, Appendix C.

8.3. The following exceptions can reduce or eliminate the need to install a whole-house ventilation system.

8.3.1. Whole-house ventilation systems aren’t required for homes without mechanical cooling in International Energy Conservation Code (IECC) Zones 1 and 2; or for homes that are conditioned for less than 876 hours per year. These exceptions all require that the local jurisdictional authority determines that windows are an acceptable method of ventilation (ASHRAE Standard 62.2 – 2007, Section 4.1).

8.3.2. An infiltration credit may be applied to reduce whole-house mechanical ventilation requirement. The credit may be determined using ASHRAE Standard 62.2-2007, Section 4.1.3, if the building enclosure has been tested with a blower door. When the infiltration credit is larger than the nominal fan size specified in 8.1.5, a whole-house mechanical ventilation system isn't required.

## 9. Moisture Control

The energy audit shall include an inspection of each home for moisture problems and specifications for prevention and remediation, as applicable to the proposed ECMs for the following.

**Note**: Excessive moisture contributes to mold, indoor air pollution, and building durability problems.

9.1. Evidence of exterior water intrusion, such as roof leaks, foundation leaks, and ground-water intrusion.

9.2. Evidence of all interior water sources, such as plumbing leaks.

9.3. Effects of water damage on buildings, such as mold, mildew, insect damage, efflorescence, and stains, including evidence of damage due to expansive soils.

9.4. Existing vapor retarders, flashing, gutters, or other moisture-control strategies.

9.5. Measures specified in the work scope to prevent potential moisture problems or mitigate identified moisture problems, as applicable.

## 10. Building Enclosure Performance

The energy audit shall include an evaluation of the performance of the building enclosure, and include recommendations for upgrades as appropriate according to Sections 5 and 6.

The audit report shall include:

10.1. The air-leakage rate of the building enclosure as determined by a blower door test. Pre-work blower-door testing may be deferred and specified as part of the work scope.

10.1.1. When enclosure air sealing is specified, specify a blower-door test when work is completed, or as part of the final inspection.

10.2. Air-sealing work should be done prior to the insulation work.

10.3. Estimation of R-values of opaque building materials.

10.3.1. Evaluation of insulation retrofits for feasibility and energy savings.

10.4. Estimation of U-factors and solar heat gain coefficients (SHGCs) of windows and doors.

10.4.1. Evaluation of the feasibility and energy savings for window treatments, including window replacements for improvements in thermal resistance and/or shading.

10.5. In homes with mechanical cooling systems, evaluation of the feasibility and energy savings of shading and solar-reflectance retrofits for the roof and/or wall.

## 11. Heating and Cooling (HVAC) Efficiency

The energy audit shall include an evaluation of the performance of the building mechanical systems, and the report shall recommend upgrades as appropriate according to Sections 5 and 6 of this standard.

11.1. Evaluation of furnace performance and efficiency.

11.2. Evaluation of air-conditioning and heat-pump performance and efficiency.

11.3. Evaluation of duct performance, including filter effectiveness and duct sizing.

11.4. Evaluation of air duct systems that are partially or fully outside the conditioned space for air leakage and thermal insulation. The energy audit shall prescribe one or more of the following two duct-sealing requirements. Pre-work duct testing may be deferred and specified as part of the work scope.

11.4.1. Evaluation of duct systems that are no more than 25% outside conditioned space with a pressure-pan test to identify useful duct sealing opportunities. Conduct this evaluation with a blower door depressurizing the building enclosure to 50 Pa. If the pressure at any duct register is more than 3 Pa or the average of all registers is more than 1 Pa, duct-sealing opportunities are likely and further testing is recommended.

11.4.2. When ducts are more than 25% outside conditioned space, the energy audit shall include a duct-pressurization test to evaluate duct leakage as part of the energy audit, or specify a duct pressurization test prior to beginning duct-sealing work.

11.5. When duct sealing is specified, specify a duct-pressurization test when work is completed or as part of the final inspection.

11.6. Evaluate duct location and R-value; evaluate feasibility and energy savings of retrofit duct insulation, as applicable.

11.7. Evaluation of evaporative-cooler maintenance, installation, and performance, as applicable.

11.8. Evaluation of boiler performance and efficiency, as applicable.

11.9. Evaluation of steam-heating distribution performance, as applicable.

11.10. Evaluation of hot-water space-heating distribution performance, as applicable.

11.11. Evaluation of hot-water heater and hot-water distribution performance, as applicable.

11.12. Evaluation of the feasibility and energy savings of HVAC equipment replacement. Specify that replacement systems comply with Air Conditioning Contractors of America (ACCA) *5 QI HVAC Quality Installation Specification*.

11.13. For equipment that isn't specified for replacement, specify cleaning, tuning, adjustment, control upgrades and repair in the work scope.

## 12. Baseload Energy Efficiency

The energy audit shall include an evaluation of baseload energy uses and the report recommends upgrades as appropriate according to Sections 5 and 6.

12.1. During the audit, the customer shall be advised about behavioral changes that reduce energy consumption including:

12.1.1. Plug loads and associated electricity costs.

12.1.2. Calculated baseload energy consumption with the following energy uses disaggregated from one another: baseload, water heating, space heating, cooling, and other seasonal consumption, such as pool heaters and pumps.

12.1.3. Household baseload energy use as compared with similar homes in the region.

12.1.4. Value of turning off lights, televisions and other loads when not in use.

12.2. The energy audit shall include an evaluation of:

12.2.1. Refrigerator and freezer performance.

12.2.2. Lighting efficiency and efficient alternatives.

12.2.3. Clothes-dryer vents [restrictions, lint build-up, or indoor termination and for appropriate venting materials].

12.2.4. Pool and spa energy consumption and conservation strategies.

12.2.5. The efficiency of other major baseload energy users.

12.3. The energy audit report shall include a recommendation of appropriate replacements or alternatives to appliances.

# ~~Annex A~~
# ~~Normative~~
# ~~Alternate Ventilation According to ASHRAE 62–1989~~

~~The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62-1989 is a legacy standard allowed in Section 8 of this Standard as an alternate to ASHRAE 62.2-2007 until July 1, 2013. ASHRAE Standard 62-1989 requires homes to have at least 0.35 air changes per hour (ACH), and at least 15 CFM per person.~~

~~A.1 According to standard ASHRAE 62-1989, ventilation shall be satisfied by a combination of mechanical ventilation and/or the enclosure air leakage. The ventilation contributed by air leakage may be estimated by conducting a blower door test. The $CFM_{50}$, needed to meet this requirement, without mechanical ventilation, is referred to in this standard as Minimum Ventilation Requirement or MVR [previously called "Building Airflow Standard" (BAS)]. Follow these steps to determine the MVR and determine ventilation needs:~~

~~A.2 Determine the number of occupants by choosing whichever is larger:~~

~~a) the actual number of occupants, or~~

~~b) the number of bedrooms plus one.~~

~~A.2.1 Find the zone from the map shown below.~~

**~~Figure 1. N-Factor Zone~~**

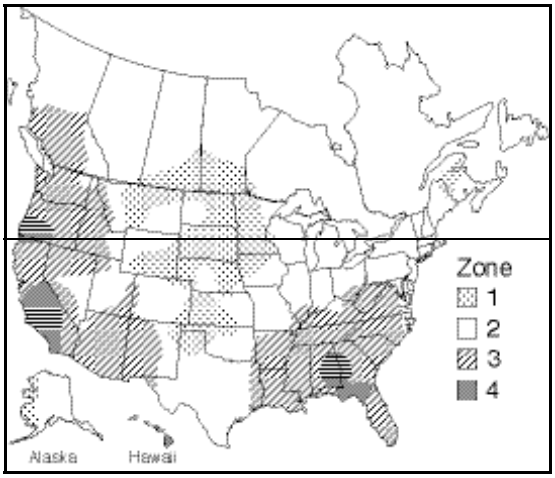

**Table 2. N-Factor**

| | Number of stories | | | |
|---|---|---|---|---|
| Zone | 1 | 1.5 | 2 | 3 |
| 1 | 18.6 | 16.7 | 14.9 | 13 |
| 2 | 22.2 | 20 | 17.8 | 15.5 |
| 3 | 25.8 | 23.2 | 20.6 | 18.1 |
| 4 | 29.4 | 26.5 | 23.5 | 20.6 |

A.2.2 Using the table, choose the factor "N" corresponding to the building's stories and shielding factor for each geographic zone. This factor converts estimated natural air flow to 50 pascal flow ($CFM_{50}$) using the following equations. MVR is in units of $CFM_{50}$ (CFM at 50 Pa):

1) $$MVR = 15 \times Occupants \times N$$

2) $$MVR = \frac{0.35 \times Volume \times N}{60}$$

A.2.3 Calculate MVR using each formula and choose the larger $CFM_{50}$ result as the MVR.
A.2.4 Make recommendations for whole-house ventilation based on the following table:

**Table 3. Recommendations for Home Ventilation (ASHRAE Legacy)**

| Blower Door Measurement* | Recommendation |
|---|---|
| Final blower door measurement is greater than the calculated MVR. | Air leakage is acceptable for whole house ventilation and air sealing may be conducted down to calculated MVR. Require local (spot) ventilation in kitchen and baths by a whole-house ventilation fan, a local exhaust fan, or operable windows. |
| Final blower door measurement is between 70% and 100% of the calculated MVR. | Recommend continuous whole house mechanical ventilation, sized to provide the following CFM: (MVR - CFM50) / N |
| Final blower door measurement is less than 70% of the calculated MVR | Recommend continuous whole house mechanical ventilation, designed to provide the larger of the following:<br>(MVR - CFM50) / N<br>or (15 x Occupants) |

A.2.5 If the anticipated tightness after work is completed is likely to be at or below MVR, ventilation shall be recommended in the work scope.

# Annex B
# Normative
# BPI Home Energy Audit Standard-Referenced Documents

| Item | Date | Website | EA Standard Section |
|---|---|---|---|
| EPA Guidelines for Radon Testing | | | 3.9 |
| ASHRAE Standard 62.2.-2007 | 2007 | | 8.1.4. 8.1.5. 8.2. 8.3.1.8.3.2, A, A.1 |
| ~~ASHRAE Standard 62-1989~~ | ~~1989~~ | | ~~8.1.4.1, A~~ |
| International Energy Conservation Code | 2006 | | 8.3.1, 10.3. *(compare component R-values to those specified in IECC)* |
| ANSI/ACCA 5 QI-2007, HVAC Quality Installation Specification | 2007 | | 11.12 |
| ANSI Standard Z223.1-2002, Annex H, Recommended Procedure for Safety Inspection of an Existing Appliance Installation | 2002 | | *Insert in 7.5* |
| National Fuel Gas Code or International Fuel Gas Code | | | *Insert in 7.2 (procedure for testing gas or propane leakage in piping systems)* |
| ANSI/ASTM E779-03, Standard Test Measure for Determining Air Leakage Rate by Fan Pressurization | 2003 | | *Insert in 10.1* |

# Annex C
# Normative
# Terms and Definitions

ACCA – Air Conditioning Contractors of America

ACH – Air changes per hour

ANSI – American National Standards Institute

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

BPI – Building Performance Institute, Inc.

CAZ – Combustion appliance zone

CFM – Cubic feet per minute

CO – Carbon monoxide

Home – See low-rise residential building, below

IECC – International Energy Conservation Code

EA – Energy auditing

ECM – Energy Conservation Measure

Low-rise Residential Building – a single family detached or attached building *or* a multifamily building less than four stories tall.

PV – Photovoltaic

SHGC – Solar heat gain coefficient