Building Performance Institute, Inc.

BPI Standards

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Standard Practice for Multifamily Energy Auditing

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Formulated under the cognizance of the BPI Standards Technical Committee.

Introduction

(Informative)

The Building Performance Institute, Inc. (BPI) publishes standards for the existing residential building retrofit industry. Although this standard is primarily focused on energy conservation measures and criteria, it does extend beyond these measures to address the building as a whole. The auditor's role may vary depending on the context in which the audit is 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. The recipient of the audit can include property owners and/or program administrators.

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1 Scope

This Multifamily Energy Auditing Standard defines the minimum criteria for conducting a building-science-based evaluation of existing multifamily buildings and provides specific technical procedures to conduct a multifamily building energy audit as necessary to define the minimum skills required by a BPI Multifamily Energy Auditor. Additionally this standard is the basis for BPI's Multifamily Energy Auditor Certification.

Multifamily buildings are defined as buildings that have five or more residential units. For any case where the above definition does not coincide with the local jurisdiction's definition of a multifamily building, the local jurisdiction's definition shall take precedence, and this standard may be applied to that building.

BPI-1200-S Standard Practice for the Basic Analysis of Buildings will typically apply to 2 - 4 unit buildings based on its scope copied here: "Existing detached single-family dwellings and townhouses that have independent mechanical systems for each dwelling unit (heating, cooling, water heating, and ventilation); direct access to outdoors for each dwelling unit; and were designed to have continuous party walls with no penetrations to adjacent units, with such party walls extending from ground to roof where the dwelling unit is attached to one or more adjacent single-family dwelling units."

For buildings that do not meet the BPI-1200 definition, the multifamily standard may be used.

This on-site evaluation standard aligns with the definition of an American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Level II audit (see definition below). The scope of the on-site evaluation will include an evaluation of the residential units, common area public spaces and all central building systems affecting energy use in the residential space. The on-site evaluation will address energy usage, and limited aspects of building durability and occupant health and safety. The on-site evaluation will provide a comprehensive report with a list of prioritized recommendations to improve the building and will include a cost-benefit analysis of all proposed measures.

1.1 Program Guidance

Program requirements, laws or regulations, and applicable building codes or ordinances may take precedence over these standards in setting requirements for on-site evaluations, work scopes and Energy Conservation Measures (ECMs). Consumers and third-party funding sources often require additional accounting requirements of ECM costs and savings, energy savings, demand savings, and/or emissions reductions. Additionally, regional climate, housing types and market conditions vary. The Energy Auditor and/or Programs will need to use their discretion as to which components of the energy audit will need to go beyond the minimum criteria set forth in this Standard.

Conversely, the minimum criteria defined in this Standard may go beyond the requirements of an energy efficiency program. In this circumstance, the BPI Multifamily Energy Auditor Certification may still be referenced as a minimum qualification for individuals qualified to

perform the specified audit requirements for that program, but the program will need to define the minimum outcomes and requirements of the audit and may use this standard for guidance. Programs seeking to define minimum requirements are encouraged to align the audit requirements for the program with the industry-recognized definitions of Level I and Level II audit thresholds as described in *ASHRAE Procedures for Commercial Building Audits, Second Edition*[1]. The minimum requirements set forth in this standard are equivalent to the Level II audit.

- Level I Audit: "Assess a building's energy cost and efficiency by analyzing energy bills and conducting a brief on-site survey of the building. A Level I energy analysis will identify and provide a savings and cost analysis of low-cost/no-cost measures. It will also provide a listing of potential capital improvements that merit further consideration, and an initial judgment of potential costs and savings" (ASHRAE Procedures for Commercial Building Audits[1]). The survey will include a list of easily identifiable and immediate building durability and occupant health and safety concerns as well as potential items that may merit further investigation.

- Level II Audit: "This includes a more detailed building survey and energy analysis. A breakdown of the energy use within the building is provided. A Level II energy analysis will identify and provide the savings and cost analysis of all practical measures that meet the owner's constraints and economic criteria, along with a discussion of any changes to operation and maintenance procedures. It may also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings. This level of analysis will be adequate for most multifamily buildings and measures" (ASHRAE Procedures for Commercial Building Audits).

In addition to easily identifiable and immediate durability and health and safety issues, the on-site assessment will require that an auditor conduct certain diagnostic tests. Where not specified in the standard, the diagnostic tools selected for these tests should match the scale of the building and the equipment contained within. Based on the results of this diagnostic testing the energy audit report will recommend further investigation and/or repair as needed.

This is a standard for evaluating an existing building and making recommendations to upgrade the building to improve the energy efficiency and health and safety of the building. This standard does not require buildings to be upgraded to a specific standard but rather be evaluated against a specific standard.

1.2 Organization of the Standard

While this is a standard for whole building evaluation, the standard is divided into individual sections to reduce duplication of information. This standard is organized into 23 sections to

[1] ©ASHRAE (*Procedures for Commercial Building Energy Audits)*, (Second Edition), (2011)

capture all elements of a multifamily energy audit including pre-site visit, on-site evaluation, diagnostic testing, and final energy audit report.

Each section includes requirements and recommendations for the auditor to complete and include in the energy audit report and shall be used to guide the on-site evaluation of the building and the final scope of work recommendations. Where possible and appropriate, the topics in each section are consistent and include at a minimum the following:

- General or General Requirements: which may include general description of the approach to the section and/ or requirements of components to be addressed during the on-site evaluation.
- Energy Audit Report: which identifies components that should be included in the report. Throughout the standard there has been deliberate use of the terms "shall" and "should". For this standard "shall" requires an auditor to complete the task in accordance with this standard and "should" allows the auditor to exercise his or her judgment on the necessity of the practice relative to the building and/or the existing conditions.

2 Health and Safety Related Requirements

Disclaimer: While the on-site evaluation is not intended to be a health and safety assessment, a well-trained auditor with a strong foundation in building science will have an understanding of urgent health and safety problems that are commonly found in multifamily buildings. The auditor should, therefore, alert building staff to adverse conditions when they are identified. When adverse health and safety conditions are identified that are beyond the expertise of the auditor, the energy audit report should contain recommendations to consult with a qualified specialist. It is not to be expected that the energy auditor is a trained professional in any of the health and safety areas outlined in Section 2 (Health and Safety Related Requirements) of this standard.

The energy audit report shall communicate basic health and safety concerns and shall include recommendations to maintain or improve existing levels of health and safety and mitigate identified hazards.

2.1 General Requirements

The on-site evaluation shall:

2.1.1 General Safety

Not endanger the occupants or the auditor.

2.1.2 Interview

Include an interview of the owners, property managers, maintenance staff and occupants in accordance with Section 6 (On-Site Evaluation) of this standard about their awareness of energy-related building hazards or other health and safety issues.

2.1.3 Combustion Appliances and Fuel Distribution System Testing

Include a test of the fuel distribution system/s and all combustion appliances in accordance with Section 12 (Combustion Appliance and Fuel Distribution System Testing) and Section 10 (Sampling Procedure) of this standard.

2.1.3.1 Smoke/CO Alarms

Include the verification of the presence of CO alarms and smoke detectors in accordance with Section 12 (Combustion Appliance and Fuel Distribution System Testing) of this standard.

2.1.4 Ventilation

Include a test and evaluation of ventilation requirements in accordance with Section 13 (Indoor Air Quality and Ventilation) and Section 10 (Sampling Procedure) of this standard.

2.1.5 Document Health and Safety Conditions

Include documentation of existing conditions and evaluation of the following basic health and safety issues:

2.1.5.1 Moisture

Signs of moisture problems or mold in accordance with Section 11 (Moisture Control) of this standard.

2.1.5.2 Pests

Pest conditions and associated existing controls and strategies. Pest problems identified by visual inspection and/or occupant complaints shall be documented in the energy audit report when applicable.

2.1.5.3 Lead

The auditor shall take care not to disturb existing lead-containing materials during the on-site evaluation. When measures are proposed that may affect paint in buildings built prior to 1978, the energy audit report shall include a recommendation to adhere to lead safe work practices.

2.1.5.4 Asbestos

The auditor shall take care not to disturb asbestos-containing materials. If recommended ECMs will disturb asbestos-containing materials identified by the energy auditor during a visual inspection, the energy auditor shall identify those materials and include a recommendation in the energy audit report to adhere to best practices for asbestos-containing materials or State regulations.

2.1.5.5 Electrical

Unless the auditor is qualified as an electrician, the auditor shall limit the electrical recommendations to the identification of knob and tube wiring and other visual observations of electrical components such as frayed wiring, open junction boxes, presence or lack of ground fault circuit interrupter (GFCI), and electrical issues in which they have been trained.

2.1.5.6 Lighting Conditions

The auditor shall complete visual evaluation and consider lighting levels from a safety perspective in residences, common areas, hallways, stairwells, entries and parking areas. The energy audit report shall include recommendations to improve lighting for safety and in accordance with Section 20 (Lighting) of this standard.

2.1.5.7 Radon

When the presence of radon is suspected, the auditor should inform customers about potential radon risk and provide information in accordance with Environmental Protection Agency (EPA) guidelines, unless an EPA guidelines-compliant radon-mitigation system is already in place.

2.2 Energy Audit Report

The energy audit report shall:

2.2.1 Health and Safety Hazards

List all existing health and safety related hazards identified during the on-site evaluation and make appropriate recommendations to address the health and safety related issues identified. Document health and safety related hazards and operations, maintenance, energy and cost burdens that may develop when the preventative measures are taken.

2.2.2 Hindrance of ECMs

Document existing health and safety related hazards that may hinder the installation of planned ECMs.

2.2.3 Potential Health and Safety Hazards

Document health and safety related hazards that may develop when the ECMs are installed and specify preventative measures.

2.2.4 Work Safe Practices

Specify appropriate safe work practices in the energy audit report. Include 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 procedure.

3 Disclosure and Ethics

The energy audit report shall provide clear and accurate information to the owners and occupants about ECMs and health and safety improvements.

3.1 Energy Audit Report

The energy audit report shall:

3.1.1 Conflict of Interest

Disclose any potential conflict of interest of the auditor or firm and include in report.

3.1.1.1 Products and Services Sold

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

3.1.2 Meeting of Standard

Include a statement that the energy audit report and on-site evaluation meets the minimum requirements of this standard. The auditor shall indicate in the energy audit report any areas of this standard that were not met, and the reason for not meeting these areas.

3.1.3 Report Contributors

Disclose all those who contributed to the generation of the energy audit report, including but not limited to: field staff, engineers, subcontractors and reviewers. Include key individuals' signatures and credentials.

3.1.4 Vendor Neutral

Contain recommendations that are manufacturer/vendor neutral.

3.1.5 Cost-Effectiveness

Communicate as accurately as possible about the cost-effectiveness and feasibility of the recommended ECMs, based on energy simulation and other calculations, utility analysis, and site-specific applicability. The energy audit report should provide evidence of successful previous applications and subsequent savings of specific ECMs as warranted.

3.1.6 Assumptions

Clearly disclose all assumptions used to generate cost-benefit analysis in accordance with Section 7 (Energy Audit Report) of this standard.

3.1.7 Technical Merit

Include disclaimer language addressing technical merit of energy audit report recommendations and accuracy of cost-benefit analysis while describing potential for modifications due to changes in pricing, field conditions, applicable codes, and requirements for professional engineering review and specification development when required.

3.1.8 Importance of Measures

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

3.1.9 Interactions

Disclose ECM interactions with other building components including both potential positive and negative effects and additional long term operations and maintenance requirements.

3.1.10 Measures Requested by Client

In addition to ECMs identified by auditor, the auditor should also include a non-biased cost-benefit analysis of any specific measures requested by the client.

4 Pre-Site Visit

Prior to the on-site evaluation, specific information should be collected and analyzed in order to assist the auditing process.

4.1 General Requirements

To gather information, confirm expectations and scope of the on-site evaluation, a pre-site visit meeting or conference call should be scheduled and include the following key participants:

a. Auditor and building owner or primary decision maker(s).
b. Local jurisdictional staff, engineers, subcontractors or reviewers (where appropriate).

When possible this should occur prior to the finalization of the contract with the client. The auditor should make reasonable effort to schedule the pre-site visit meeting or conference call at a time that is convenient for all parties.

4.2 Discussion Points

During the pre-site visit meeting the following items should be discussed and confirmed:

4.2.1 Contact Information

Contact information for key building representatives, including: the building owner, manager(s), maintenance staff (including outside maintenance contractors as necessary), and occupant representatives.

4.2.2 Project Goals

The building owner, client, or decision maker(s)' goals, expectations and priorities with respect to the on-site evaluation and energy audit report.

4.2.3 Maintenance Issues

Any significant or chronic operations and maintenance issues such as leaks, indoor air quality, or pests that may require special consideration or diagnosis/equipment at the time of the on-site evaluation.

4.2.4 Health and Safety Issues

Any significant fire, structural, or health and safety concerns within the building.

4.2.5 Building Renovations

Any current or planned building renovations.

4.2.6 Wage Rates

Wage rates to be factored into the construction cost estimates, as necessary.

4.2.7 Funding Sources

Any subsidy or incentive funding, and how it will impact the on-site evaluation, testing, energy audit report, and cost-benefit analysis.

4.2.8 Demographics

Occupancy/vacancy rates and demographics such as special needs population, senior population, single room occupancy, families.

4.2.9 Areas of Access

Inform meeting attendees of potential areas that will need to be accessed during the on-site evaluation, such as crawl spaces, attics, mechanical rooms, and apartment units, so that they can provide access to these spaces and inform the appropriate parties.

4.2.10 Unit Access

Inform meeting attendees that residents should be notified at least one week prior to the on-site evaluation of unit inspection that will be conducted during the on-site evaluation.

4.2.11 Translation

When the auditor will be conducting an interview of the residents, verify if there will be a need for a translator.

4.3 Items to Collect

During the pre-site visit meeting or conference call, the following items should be collected by the auditor:

4.3.1 Utility Bills

The most recent historical energy and water utility data, including bulk-delivered fuels in accordance with Section 5 (Utility Analysis) of this standard, including benchmarking data when available.

4.3.2 As-Built Drawings

As-built drawings, including drawings of any completed renovations or proposed renovations.

4.3.2.1 Verification of Drawing Information

When available, information collected from the building drawings shall be verified during the on-site evaluation based on actual observed conditions. Wherever on-site conditions do not match design conditions, on-site data shall be used for analysis and reporting.

4.3.2.2 Buildings with No Drawings

Where building plans do not exist, the auditor shall measure and document physical geometry of building and components to the extent necessary to create accurate energy simulations, calculations, and cost-benefit analysis of ECMs.

4.3.2.3 Items to Confirm

When available, the auditor shall verify from the as-built drawings the existence and location of each of the following building elements:

a. Total building square footage
b. Number of units and bedrooms
c. Unit configurations
d. Cubic volume of conditioned space
e. Renovations and/or additions that have been made since the original construction of the building
f. Potential air leakage paths
g. Rated R-values and areas of building component assemblies for input into heating/cooling load calculations
h. Location of the thermal boundary and location of potential thermal bridges
i. Types and schedule of mechanical equipment and distribution system(s)

4.3.3 Previous Analyses

Any previous energy audit reports, physical needs assessments, capital needs assessments, or other related analysis.

5 Utility Analysis

Complete energy and water consumption data shall be collected and analyzed prior to the on-site evaluation. When complete data in accordance with Section 5.1 (Utility Analysis - General Requirements) of this standard is not available, refer to Section 8 (Energy Simulation) of this standard for additional requirements regarding interpretation of modeled results.

5.1 General Requirements

The utility data used for the cost-benefit analysis shall meet the following requirements:

5.1.1 Continuous Data

The data shall encompass a minimum of 12 consecutive months (24 preferred) of utility data, composed of 365 contiguous days.

5.1.2 Data Frequency

Utility data shall be at least bi-monthly as metered by the utility or provider, not just an annual summation.

5.1.3 Delivery and Read Dates

The utility data analysis period should be chosen taking into account the fuel delivery dates and meter read dates to minimize the amount of adjustment necessary to have the bills correspond to the same 365-day period.

5.1.4 Analysis Periods

Analysis intervals shall be in full 12 month periods.

5.1.5 Date Ranges

All fuels shall be analyzed in the same date range.

5.1.6 Energy Sources to be Analyzed

Data should include all metered or delivered energy sources, including, but not limited to: electricity, natural gas, district steam, district hot water, district chill water, propane, fuel oil, solid fuels such as coal or wood, domestic water and sewer.

5.1.7 Itemized Cost Information

Where per-unit charges are identifiable against flat fees, data should include commodity, demand, and detailed itemized cost information.

5.2 Weather Normalization

Energy usage data shall be weather-normalized using weather data for the weather station closest to the building location (or adjusted and documented according to local anomalies) and billing period being evaluated. The weather station used for the analysis shall be included in the report.

5.3 Billing Anomalies

Before the on-site evaluation, energy and water consumption should be evaluated based on utility billing data, and analyzed to identify anomalies. The auditor should document and explain identified anomalies and whether they were confirmed during the on-site evaluation.

5.4 Rate Analysis

If available, the auditor shall collect and provide a hard copy of at least one complete bill which lists all charges and flat fees. The effect of the building's current rate structure and associated fixed charges (taxes, surcharges, delivery fee, meter reading fee) on overall billing should be considered.

5.5 Low Consumption Periods

If documented consumption is lower than anticipated due to atypical equipment downtime, vacancies, and/or other identifiable factors, then any estimation methodology that has been developed to adjust for these factors shall be clearly documented in the energy audit report.

5.6 Individual Meters

When units are individually metered and billed, and complete billing information is not provided for the units, the auditor shall apply unit level fuel analysis sampling in accordance with Section 10 (Sampling Procedure) of this standard.

5.7 Utility Benchmarking

Appropriate industry-recognized indices shall be calculated for each energy use (e.g., Energy Use Index - kBtu/SF/yr) and for water use (e.g., gallons/person/day) and shall be included in the energy audit report.

5.8 Disaggregated Data

Disaggregated consumption shall be calculated based on actual data for: baseload for each energy source, cooling consumption, and heating consumption.

5.9 Demand and Generation Analysis

The auditor shall complete an evaluation of savings opportunities related to electricity demand control and renewable technologies.

5.10 Rate Analysis

The calculation of the marginal rates by fuel type and by rate class (owner vs. tenant) shall be determined and documented clearly. These marginal rates shall be referenced and used in the cost-benefit analysis. If the current structure seems incorrect, the auditor should recommend the building owner investigate further and conduct a utility rate analysis if needed.

5.11 Energy Audit Report

The energy audit report shall:

5.11.1 Include Data

Include all raw data used in the utility analysis, including at least one actual bill for each utility analyzed, if available.

5.11.2 Estimated and Actual Bills

Document whether each bill included in the utility analysis is an actual or estimated bill.

6 On-Site Evaluation

Prior to the on-site evaluation, the auditor shall collect and analyze the information included in Section 4 (Pre-Site Visit) of this standard.

6.1 General Requirements

The on-site evaluation shall be based on building-science principles and include the use of visual assessments and, where appropriate, calibrated equipment in diagnosing opportunities for improving energy efficiency and minimizing health and safety hazards. During the on-site evaluation, specific information shall be collected on-site to assist with the energy modeling and decision-making process.

6.2 Interview

An interview shall be completed with each available representative decision maker as defined in Section 4.2.1 (Pre-Site Visit - Contact Information) of this standard.

6.2.1 Interview Topics

The interview shall be used to obtain information about building maintenance and operations, past building renovations and capital improvements and future renovation or capital improvement plans, building occupant, staff, and/or owner complaints, awareness of energy-related building hazards or other health and safety issues, and aspects of the building that function well, adequately, or poorly.

6.2.2 Resident Interviews

If approved by building management, a sample of resident interviews shall also be conducted.

6.3 Confidentiality

Confidentiality of personal information obtained during inspections and interviews shall be maintained by the auditor.

6.4 Context

When working with building owners, occupants, and staff, the auditor shall be respectful of, and make a reasonable effort to understand the context of, the people and situations involved, including conditions which may affect the auditor’s ability to adequately obtain accurate and complete data, especially during the interview process.

6.5 On-Site Data

Data obtained during the on-site evaluation shall include sufficient information to produce a comprehensive work scope to address comfort, limited aspects of occupant health and safety, durability, energy efficiency, operations and maintenance, and cost-savings opportunities.

6.5.1 Areas of Access

Areas accessed and data collected during the on-site evaluation shall be in accordance with all sections outlined in this standard.

6.5.2 Visual Inspection

The on-site evaluation shall include a visual inspection of the functional areas of the building, accessible crawl spaces, attics, mechanical rooms, storage areas, and a sampling of apartment units per Section 10 (Sampling Procedure) of this standard.

6.5.3 Maintenance Logs

The auditor shall review and document maintenance logs for all building systems where available.

6.6 Observed Hazards

Immediate health and safety issues shall be documented and reported immediately to the appropriate building representative.

6.7 Auditor Expertise

When site conditions or ECMs are identified that are beyond the expertise of the auditor, the energy audit report shall contain recommendations to consult with a qualified specialist.

6.8 Documentation

The auditor shall sufficiently document existing conditions with digital photographs.

6.9 Energy Audit Report

The energy audit report shall:

6.9.1 Interview Results

Include the results of all interviews conducted in accordance with Section 6.2 (On-Site Evaluation - Interview) of this Standard.

6.9.2 Observed Hazards

Include a list of all health and safety, building durability, readily observable code issues, or other conditions that may be detrimental to the building or its occupants that were identified during the on-site assessment.

6.9.2.1 Health and Safety Recommendations

The auditor shall make appropriate recommendations to address the health and safety related issues identified in accordance with Section 2 (Health and Safety Related Requirements) of this standard.

6.9.2.2 Resilience Recommendations

Auditor recommendations shall be made within the context of the building's ability to remain safe and habitable in the event of an extended service disruption in the area.

6.9.2.3 Digital Photographs and Other Documentation

Include all documentation of the building's existing conditions, including digital photographs.

7 Energy Audit Report

A comprehensive energy audit report shall be provided to the building decision maker(s) based on the findings gathered during the on-site evaluation and subsequent analysis as outlined in this standard.

7.1 General Requirements

The energy audit report shall include, at a minimum:

7.1.1 Assessment of Building Conditions

An evaluation of existing building conditions and components affecting energy and water use in accordance with this standard.

7.1.2 Utility Analysis

A utility analysis for the property accounts and, if available, tenant accounts in accordance with Section 5 (Utility Analysis) of this standard.

7.1.3 Cost-Benefit Analysis

A cost-benefit analysis of energy and water saving measures in accordance with Section 9 (Cost-Benefit Analysis) of this standard.

7.1.4 Description of Non-Energy Benefits

A description of any non-energy benefits of the recommended measures including, but not limited to: health and safety improvements, societal benefits, environmental benefits, tenant satisfaction and reduced turnover, and avoided penalties.

7.1.5 Site Energy Consumption

The total weather-normalized site energy consumption of the baseline simulation as well as the predicted savings of the proposed group of ECMs by fuel type and by the heating, cooling, and baseload end-uses in accordance with Section 8 (Energy Simulation) of this standard.

7.1.6 Summary of Measures

An easily readable summary table of a comprehensive set of recommended ECMs ranked based on cost-effectiveness. The recommended measures shall be based upon best-practice installation procedures and be specific to the client and site specific circumstances. Recommended measures that were removed from the energy audit report should be documented with an explanation of why they were removed.

7.1.7 Applicable Incentives

Information on energy programs, incentives, regulations and energy costs relevant to prioritized recommendations for improving the building.

7.1.8 Health and Safety Recommendations.

A list of health and safety recommendations based upon the on-site evaluation in accordance with Section 2 (Health and Safety Related Requirements) of this standard.

7.1.9 Operations and Maintenance Evaluation

An evaluation of building operations, maintenance, and tenant education. The existing maintenance plan shall be considered for its adequacy to ensure the persistence of savings and durability of building components, including maintenance of: mechanical equipment, light fixtures and bulb replacements, building-owned appliances, and water

saving devices. When the plan is found to be lacking or deficient, a recommendation that a maintenance plan be developed shall be made as part of the energy audit report.

7.1.9.1 List of Assumptions

A list of all assumptions made during the utility analysis, on-site evaluation, or energy simulation.

7.1.9.2 Performance Requirements

For recommended improvements, the recommendation should include all necessary information detailing the required installation and materials used to model projected savings, and will disclose when further design and specification development is required to achieve projected savings.

7.2 Additional Report Requirements

Where applicable, the energy audit report shall include the following items:

7.2.1 New Technologies

A variety of options shall be considered when recommending improvements to the building. New and emerging technologies and approaches to ECMs and energy cost reduction shall be evaluated and recommended as appropriate in the context of the particular client's needs, energy costs, technological capabilities of the site and its staff, the building owner's social mission, etc.

7.2.2 References

Supporting reference documentation when appropriate.

7.2.3 Previous Reports

If previous energy audit reports, physical needs assessments, capital needs assessments, or other related analyses have been performed at the site, the report should include a summary of previous reports.

7.2.4 Energy Benchmarking

Where applicable, the audit report should include benchmarking information on the building's energy performance relative to buildings with similar construction and vintage, building systems, and climate conditions in accordance with Section 5.7 (Utility Analysis - Utility Benchmarking) of this standard.

7.2.5 Healthy Housing Inspections[2]

Where the on-site evaluation includes an inspection using U.S. Department of Health and Human Services/U.S. Department of Housing and Urban Development Healthy Housing Inspection protocols, the energy audit report should include an assessment of

[2] Refer to *Healthy Housing Inspection Manual*: http://www.cdc.gov/nceh/publications/books/inspectionmanual/healthy_housing_inspection_manual.pdf

pest risk, indoor air quality, and recommend appropriate measures for improving health and safety.

7.2.6 Scope of Work Implementation Recommendations

While it is not necessarily within the purview of the energy audit, it is recommended that the auditor include a summary of suggested or required steps and costs necessary to implement a successful project that will achieve predicted savings and other project goals. This can include, but is not limited to:

7.2.6.1 Collaboration with Rebate Programs

When the project is going through a rebate or other incentive program, it is recommended that the auditor assist the building owner in understanding program requirements and ensuring that recommended measures meet minimum program requirements.

7.2.6.2 Budget and Scope Development

It is recommended that the auditor provide suggested steps or assistance to develop a final scope of work based on the owner's budget and goals.

7.2.6.3 Design, Specification, and Bid Development

It is recommended that the auditor indicate in the energy audit report any anticipated design and specification efforts that may be required to implement the recommended scope of work.

7.2.6.4 Contractor Selection

Where specialty contractors are required to properly perform a recommended scope of work, the auditor should suggest the minimum contractor requirements needed to successfully perform the scope.

7.2.6.5 Construction Verification

It is recommended that the auditor summarize or outline a potential quality control plan or necessary activities to ensure the proposed scope of work is installed correctly.

7.2.6.6 Commissioning (Cx)

The energy audit report should identify when a formal commissioning process is needed to ensure successful function of a measure.

7.2.6.7 Staff Training

The energy audit report should identify when staff training is needed to ensure successful function of a measure.

8 Energy Simulation

Where an energy simulation is required for the determination of the annual weather-normalized energy savings for a comprehensive package of proposed ECMs, the following requirements shall be met:

8.1 General Requirements

The energy simulation analysis shall be completed using energy simulation software that meets at least one of the following requirements:

a. Listed as approved for the appropriate multifamily housing construction type of the project in the U.S. Department of Energy's (DOE) Weatherization Program Notice 11-1, found at http://www.waptac.org,

or

b. Registered as a Residential Energy Services Network (RESNET) Accredited Tax Credit Compliance Software Tool http://www.resnet.us/professional/programs/taxcredit_compliance_software,

or

c. Listed on US DOE's website as a Qualified Software for Calculating Commercial Building Tax Deductions. http://www1.eere.energy.gov/buildings/commercial/qualified_software.html

8.2 Simulation Calibration

The baseline energy simulation shall be calibrated in accordance with Sections 3.2.3, 3.3.2, and 3.4 of ANSI/BPI-2400-S-2012 *Standard Practice for Standardized Qualification of Whole-House Energy Savings Predictions by Calibration to Energy Use History* and shall use the same utility data analysis period and typical weather data according to the requirements of Section 5 (Utility Analysis) of this standard. The auditor should ensure that simulated energy usage does not exceed actual energy consumption from utility data.

8.2.1 Special Conditions

If the auditor believes that there are special conditions that dictate the use of input values that are outside the range of the input constraints specified in Section 3.4 of ANSI/BPI-2400-S-2012, these special conditions and appropriate references shall be documented in the energy audit report.

8.3 Basis of Simulation Inputs

Pre-retrofit simulation inputs shall be based on the results of on-site visual verifications, measurements, and as-built drawings in accordance with Section 4.3.2.2 (Pre-Site Visit – Buildings with no Drawings) of this standard.

8.4 Minimum Simulated Components

The calibrated pre-retrofit simulation shall account for all building envelope components, heating, ventilation and air conditioning (HVAC) and domestic hot water systems, miscellaneous equipment loads, and internal and solar gains of the building(s) being evaluated for retrofit.

8.5 Simulation Input Consistency

Inputs of the pre- and post-retrofit simulations shall be the same, with exceptions for new components or operating conditions recommended by the proposed ECMs.

8.6 Increased Consumption

Any increase in energy consumption due to health and safety or code-related measures that are part of the proposed work scope, such as higher proposed ventilation rates, shall be included in the post-retrofit model.

8.7 Interactivity

The predicted energy savings for the proposed ECMs shall be calculated to accurately reflect interactivity of energy savings attributed by all recommended ECMs.

8.7.1 External Calculations

Any ECMs not directly supported by the energy simulation software shall still be modeled as part of the proposed simulation by creating the proper workaround in the simulation software in order to account for the interactivity with proposed ECMs. The modeling inputs or adjustments necessary for this shall be informed by the results of external calculations.

8.8 Energy Audit Report

The energy audit report shall:

8.8.1 Assumptions

Clearly document all assumptions made regarding building operating conditions, such as lighting runtime hours, interior temperature, hot water demand, or any other energy simulation values that may affect energy savings values.

8.8.2 Adjustments

Clearly document all adjustments to the simulation inputs used to calibrate the model. All adjustments shall be justified with explicit, transparent information, and documented in the energy audit report.

9 Cost-Benefit Analysis

The cost-benefit analysis shall meet the requirements of this section.

9.1 General Requirements

The cost-benefit analysis shall document the projected annual reductions in energy cost resulting from the package of recommended ECMs by energy source and account type (owner or tenant paid).

9.1.1 Utility Rates

The cost-benefit analysis shall utilize utility rates that reflect account type (owner or tenant paid) in order to calculate annual cost savings or cost increases. For tiered rate schedules, the auditor shall utilize the utility rate in the cost-benefit analysis that corresponds directly to the rate tier affected by the projected savings of that particular ECM. No inflation values should be applied in the analysis. The utility rate, rate tariff, and any calculations used to determine the effective utility rate applied to the usage shall be clearly documented.

9.1.1.1 Non-Consumption Charges

The utility rate(s) used for determining cost savings from changes in usage shall not include demand charges, flat meter charges, or inflation. For ECMs that result in a change to the demand charge, the demand cost savings shall be determined independently of the usage savings and separately for each applicable ECM. The demand charge, rate tariff, and any calculations used to determine the effective demand charge shall be clearly documented.

9.1.2 Associated Maintenance Costs

If the ECM has an associated and quantifiable increase or decrease in maintenance costs, they should be clearly documented and included in the cost-benefit analysis.

9.1.3 Non-ECM Measures

When quantifiable, increases or decreases in annual energy cost due to health and safety or operation and maintenance recommendations shall also be documented.

9.2 Material and Installation Costs

The cost-benefit analysis shall document estimated material and installation costs for all ECMs, health and safety, and operations and maintenance recommendations. Cost estimates shall be based upon experience with previous projects, detailed conceptual estimates, R.S. Means estimation, general contractor quotes. Assumptions for cost estimates shall be documented in the energy audit report.

9.3 Economic Analysis

The cost-benefit analysis shall constitute an economic analysis for the recommended ECMs over their estimated useful lives. It shall reflect all measurable economic benefits as defined in Section 9.1 (Cost-Benefit Analysis - General Requirements) of this standard versus economic costs as defined in Section 9.2 (Cost-Benefit Analysis - Material and Installation Costs) of this standard while accounting for the time value of money.

9.3.1 Net Present Value (time value of money)

The cost-benefit analysis shall compare the net present value (NPV) of the energy savings, considering the lifespan of the ECM(s), with the cost of installing that ECM(s). The discount rate and ECM lifespan used in the analysis shall be clearly identified.

9.3.2 Capital/Physical Needs Assessments

Where the on-site evaluation is performed in conjunction with a physical or capital needs assessment, the cost-benefit analysis should consider the incremental energy savings and life cycle costs of each recommended ECM as compared to a new standard efficiency replacement.

9.4 Cost Effectiveness of ECMs

Cost-effectiveness of recommendations shall be based upon an economic analysis in accordance with Section 9.3 (Cost-Benefit Analysis - Economic Analysis) of this standard. The auditor should recommend that more cost-effective ECMs be installed before, or instead of, less cost-effective ECMs if the budget will not allow installation of all ECMs.

10 Sampling Procedure

For all visual verification and diagnostic testing requiring a representative sample, the auditor shall meet the following minimum criteria:

10.1 Common Area Sampling

The auditor shall meet the following requirements for sampling of common area spaces:

10.1.1 Unique Area Sample Size

The auditor shall inspect 100 percent of unique common area spaces such as basements, lobbies, etc.

10.1.2 Repetitive Area Sample Size

The auditor shall inspect a representative 20 percent sample (with a minimum of five areas) of similar or repetitive areas such as stairwells and stairwell landings, corridors, trash chute rooms, etc.

10.2 Unit Sampling

The auditor shall meet the following requirements for sampling of the units:

10.2.1 Unit Sample Size

The auditor shall inspect a representative 10 percent sample (with a minimum of five units) of all dwelling units. The sample shall include, at a minimum, one representative dwelling unit from each unique type, as defined in section 10.2.1.1 (Sampling Procedure - Unique Unit Type) of this standard.

10.2.1.1 Unique Unit Type

Variations in basic floor plan layout, energy design, heating and/or cooling capacity of HVAC units, or the number of HVAC units located in each dwelling unit shall cause the dwelling unit to be considered a unique type.

10.2.1.2 Mid- and High-Rise Buildings

For buildings over four habitable stories in size, the sample shall include units in the top, middle, and bottom of the building.

10.3 Multiple Building Sampling

For sites with multiple buildings, an on-site evaluation shall be completed, at a minimum, for each unique building type on the site.

10.3.1 Unique Building Type

Variations in building volume, square footage, or geometry, occupant type, energy design, heating and/or cooling capacity of HVAC units, or the number of HVAC units located in each building shall cause the building to be considered a unique type.

10.4 Inconclusive or Inconsistent Results

If the results of the initial minimum sample vary by more than 10% in the repetitive common areas or dwelling units, the results shall be considered inconclusive and/or inconsistent and additional common area spaces, dwelling units, or mechanical systems shall be evaluated to ensure a representative sample has been evaluated. The auditor shall increase the size of the initial sample such that less than 10% variation occurs across each of the repetitive common areas or dwelling units.

11 Moisture Control

Excessive moisture contributes to mold, indoor air pollution, and building durability problems. The on-site evaluation shall include a visual inspection for existing or prior moisture problems and indicators, as well as potential sources of moisture.

11.1 General Requirements

A visual inspection for moisture shall be completed throughout the building in accordance with the sampling procedures outlined in Section 10 (Sampling Procedure) of this standard. The building shall be visually evaluated for:

11.1.1 Water Intrusion

Evidence of active exterior water intrusion, such as: roof pooling, unsealed penetrations, and leaks; foundation pooling, leaks, or groundwater intrusion; and damage to the exterior sheathing or water drainage plane.

11.1.2 Interior Water Sources

Evidence of water damage as a result of any of the following interior water source: such as plumbing pipe or fixture leaks, drain pans, condensate drains, moisture around windows or wall AC sleeves, or sweating windows and/or walls.

11.1.3 HVAC Systems

Where signs of active or inactive water leakage, steam leakage, and/or leakage from any water storage, holding tank, cooling tower, or any water source HVAC distribution system are identified, the area shall be evaluated to determine the source, and documented, including leaks from: ductwork, buried steam or return lines, risers inside walls, leaking plumbing fixtures, ice dams, chilled water pipes, etc.

11.1.4 Water Damage

Evidence of water damage on building components, such as mold, mildew, insect damage, efflorescence, and stains, including evidence of damage due to expansive soils.

11.1.5 Moisture Control

Condition of existing vapor retarders, flashing, gutters, ground water control pumps (e.g., sump pump, french drain), or other moisture-control strategies. Vapor retarders should be verified to be in the proper location.

11.1.6 Condensation

Evidence of condensation on windows, walls, ventilation fans, cold water pipes, and other cold surfaces.

11.2 Diagnostic Testing to Identify Moisture Sources

Where the evidence of moisture problem is present and sources cannot be identified with a visual evaluation, diagnostic testing using moisture probes, surface moisture meters, or infrared scans should be conducted to verify and quantify existing moisture issues and to identify the source of the moisture.

11.3 Diagnostic Testing of Humidity Levels

Where the auditor feels the physical sensation of humidity or finds evidence of a humidity problem such as condensation, the humidity level should be measured using a hygrometer. This measurement should be included in the energy audit report, and recommendations to mitigate high humidity levels shall be included where measurements are above 50% relative humidity.

11.4 Energy Audit Report

The energy audit report shall:

11.4.1 Current Issues and Recommendations

Clearly document all existing or potential issues identified during the on-site assessment. Where current or potential issues are identified, recommendations to prevent or mitigate these issues shall be identified in the energy audit report and included in the cost-benefit analysis.

12 Combustion Appliance and Fuel Distribution System Testing

The on-site evaluation shall include combustion appliance and fuel distribution system testing.

12.1 General Requirements

Combustion appliance and fuel distribution system testing shall be performed in accordance with the current BPI single family combustion safety protocols with the following amendments:

12.2 Emergency Issues

The auditor shall identify, communicate, and suggest appropriate solutions to emergency issues, such as a gas leak or a dangerous level of carbon monoxide (CO) immediately to the client, owner, and/or utility representative.

12.3 Fuel Distribution System Testing

The auditor shall test for gas leakage at all accessible connections of natural gas and propane piping systems. The auditor shall inspect for oil leakage and storage deficiencies in oil-fired systems.

12.3.1 Identified Issues

The energy audit report shall recommend repair for gas and oil leaks, replacement for hazardous or damaged gas and oil connectors, and upgrades to otherwise bring fuel distribution systems up to local code.

12.4 Venting Systems

The auditor shall visually evaluate combustion venting systems for damage, proper sizing, appropriate material, inadequate slope, venting leaks, disconnected vents, and other health and safety issues. Installation should be compared against National Fire Protection Association (NFPA) requirements (Refer to *ANSI Z223.1/NFPA 54 National Fuel Gas Code*, 2012 Edition, Sections 12 and 13) and local code requirements.

12.5 Ambient CO Levels

Prior to performing combustion safety testing, and any time the auditor is in a combustion appliance zone (CAZ), the auditor shall monitor ambient CO.

12.5.1 Baseline

Prior to entering CAZ, the auditor shall measure outdoor ambient CO readings and compare to ambient CO readings in CAZ and record results.

12.5.2 Excessive CO Levels

If levels exceed the safety threshold as designated by the current BPI single family combustion safety protocols, the auditor shall evacuate unit(s)/or mechanical room being tested, and notify building management.

12.6 Appliances with Atmospheric Chimneys

Include CAZ depressurization tests, CO tests, and draft and spillage tests on combustion appliances venting into atmospheric chimneys, including fan-assisted gas appliances, in mechanical rooms and dwelling units.

12.7 Combustion Efficiency Testing

For all furnaces, water heaters, and boilers, combustion efficiency testing shall be completed at steady-state conditions and interpreted based on observed operating conditions to establish overall equipment efficiency.

12.7.1 Modulating Equipment

For modulating equipment, combustion efficiency tests should be completed at multiple firing rates when possible.

12.7.2 Dual Fuel Equipment

For equipment that can be fired on multiple fuel types, combustion efficiency and CO testing should be conducted for each fuel type.

12.7.3 Manufacturer's Specifications

The auditor shall defer to the combustion equipment manufacturer and venting system manufacturer testing procedures when performing combustion efficiency tests, and when verifying combustion chemistry.

12.8 Combustion Air

The combustion air requirements for the CAZ(s) shall be investigated to ensure that it is free and unobstructed and complies with *ANSI Z223.1/NFPA 54 National Fuel Gas Code*, 2012 Edition, Section 9.3 and local codes. Deficiencies shall be documented and recommendations for repair shall be included in the energy audit report to bring combustion air into compliance with relevant codes and standards.

12.9 Barometric Dampers

Where a barometric draft damper exists on a vent system, the auditor shall verify the presence and proper location of the barometric damper, shall verify the presence and proper location of the spill switch, check for spillage from damper upon startup, and observe proper operation of barometric damper and counterweights through at least one heating cycle. The auditor shall recommend adjustments to the barometric damper by a qualified technician when any of the following conditions exist:

a. Spillage exceeds maximum recommended

b. Excessive or minimal draft, or high excess air is found when compared to barometric damper and burner manufacturer requirements

c. Spill switches are located on the damper incorrectly, are covered in soot, or have been bypassed

12.10 Safety Devices

The auditor shall verify presence and condition of safety devices (temperature and pressure drain lines, electrical disconnects, gas shut-off, etc.) on combustion appliances. Smoke switches shall be tested for proper operation. Deficiencies shall be documented and recommendations for repair shall be included in the energy audit report, to bring safety devices into compliance with relevant codes and standards.

12.11 Dwelling Units

The auditor shall perform combustion appliance testing of dwelling units in accordance with Section 12.1 through 12.11 of this standard.

12.11.1 Minimum Sample

A representative sample, as defined in Section 10 (Sampling Procedure) of this standard, of the combustion equipment and gas stoves in dwelling units shall be tested and visually inspected.

12.11.2 CAZ Depressurization Testing in Units

CAZ depressurization testing shall be performed individually on dwelling units rather than a whole building depressurization test.

12.11.2.1 Combustion Appliances that Share a Flue

In the event that combustion appliances in different apartments share a common flue, depressurization testing shall be performed on the smallest Btu appliance on the lower floor, followed by upper floors.

12.11.2.2 Continuous Exhaust Systems

For all exhaust systems that are intended to run continuously, such as central exhaust ventilation systems, those systems should remain on and be considered "natural" conditions.

12.11.2.3 Identified Issues

If combustion safety issues, as defined by the action levels in the current BPI single family combustion safety protocols, are identified, the sampling rate as defined in Section 10 (Sampling Procedure) of this standard should be increased based on the professional discretion of the auditor.

12.11.3 Gas Stoves and Oven Testing

Carbon monoxide testing will be performed on gas stoves and ovens based on the current BPI single family combustion safety protocols.

12.12 Mechanical Rooms and Common Area Equipment

The energy auditor shall test all central system mechanical equipment in accordance with Section 12.1 through 12.10 and Section 12.12 of this standard.

12.12.1 Minimum Sample

For buildings or developments with multiple central system combustion appliances (e.g., multiple low-rise apartment buildings with central hot water heater per building), a representative sample, as defined in Section 10 (Sampling Procedure) of this standard, should be tested.

12.12.2 When Equipment Cannot be Tested

Exceptions for testing requirements are as follows:

12.12.2.1 Depressurization Test Cannot be Conducted

For mechanical rooms and common area equipment that cannot be tested under depressurized conditions, the auditor shall take baseline pressure measurements of CAZ(s) and compare them to the CAZ depressurization limit tables.

12.12.2.2 Equipment Cannot be Shut Down

For mechanical rooms and common area equipment that cannot be shut down by the auditor, combustion safety testing should be performed during an equipment firing cycle. Where equipment cannot be fired by the auditor, the energy audit report should include a recommendation for having testing performed by a qualified professional at a time at which the equipment can be fired.

12.13 Generators

If building has a generator, the auditor shall verify exhaust location and determine if building intake air source is at risk of contamination from exhaust.

12.14 Parking Garages

The auditor shall test ambient CO levels in the parking garage and any rooms that are directly connected to the garage. For more information on the ventilation and envelope requirements for parking garages, see section 13.2.3 (Indoor Air Quality and Ventilation Garages) of this standard.

12.15 Dryers

Where dryers exist, the following inspection and tests shall be performed.

12.15.1 Minimum Sample

For buildings or developments with dryers located in apartments, a representative sample, as defined in Section 10 (Sampling Procedure) of this standard, should be tested.

12.15.2 Gas-fired Dryers

If gas-fired dryers are present, the auditor shall perform the following tests and inspections:

12.15.2.1 Fuel Leakage

Test gas lines for leakage per section 12.3.

12.15.2.2 Ambient CO

Test for ambient CO per 12.5.

12.15.3 Dryer Venting

Dryer venting systems shall be visually inspected for proper installation. The auditor should confirm that the dryer venting system is installed in compliance with *ANSI Z223.1/NFPA 54 National Fuel Gas Code*, 2012 Edition, Section 10.4, manufacturer's requirements, and local codes, including the following:

12.15.3.1 Dryer Termination

The auditor shall verify that all clothes dryers vent to the outdoors.

12.15.3.2 Duct Construction

The auditor shall visually verify that duct work is sealed appropriately, is constructed of an appropriate material, and is within venting distance requirements. Flexible ductwork may only be used to connect dryer equipment to the vent system, must be less than 6’ in length without compressions or excessively bent sections.

12.15.3.3 Dryer Make-up Air

Dryer make-up air and clearance to combustibles should be measured and evaluated for deficiencies.

12.15.3.4 Common Venting

The auditor shall visually verify that dryer vent does not commonly vent with other (non-dryer) venting systems.

12.15.4 Dryer Operation and Maintenance

The auditor should document existing maintenance practices for the dryer system including frequency of exhaust duct cleaning. The auditor should inspect duct for buildup of lint where possible. The auditor should make recommendations where appropriate for increased cleaning, re-configuring, or altering ductwork to allow for regular lint cleaning, or changes to maintenance procedures.

12.16 Energy Audit Report

The energy audit report shall include:

12.16.1 Recommended Further Analysis

In cases where issues are identified that are beyond the expertise of the auditor, the energy audit report should provide recommendation for additional testing by a qualified specialist. These issues should be clearly identified in the energy audit report.

12.16.2 Results of Testing

The results of the combustion appliance and fuel distribution system testing and any identified combustion safety issues shall be fully documented in the energy audit report.

12.16.2.1 Predicted Deficiencies

Where issues are identified during the on-site evaluation, the report shall also include recommendations regarding predicted deficiencies in un-tested units.

12.16.3 Proposed Measures

Based on results of testing and predicted deficiencies, the energy audit report shall specify remediation of conditions as follows:

12.16.3.1 Recommended Repairs

The energy audit report shall make recommendations for repairs in accordance with the current BPI single family combustion safety protocols and as defined in this section.

12.16.3.2 Specify CO Alarms

Specify CO alarms in units with combustion appliances, mechanical rooms, laundry rooms with gas-fired equipment, or in units adjacent to attached garages, and one per floor level or per local code as a minimum. Prior to commencement of work, a CO alarm shall be installed in every unit with a combustion appliance that is affected by the scope of work. The CO alarm shall meet UL 2034 *Single and Multiple Station Carbon Monoxide Alarms*/ANSI 2075 *Gas and Vapor Detectors and Sensors* requirements.

12.16.3.3 Specify Smoke Alarms

Specify smoke alarms for units and mechanical rooms, and per minimum local code, that don't already have smoke alarms installed.

12.16.3.4 Address all "Stop-Work" Issues

All "stop-work" issues according to the current BPI single family combustion safety protocols shall be addressed prior to start of construction.

12.16.3.5 Measures That Do Not Affect Pressure Dynamics of Units

If scope of work does not affect the pressure dynamics of a dwelling unit with combustion equipment, and that equipment was not tested during the on-site assessment, the auditor should recommend combustion safety testing of that unit.

12.16.3.5.1 Definition of Pressure Dynamics

Pressure dynamics can be defined as changes to air pressure that can have either a negative or positive impact on combustion safety, air leakage through the building enclosure, or moisture migration to building cavities in the unit or building.

12.16.3.6 Construction Test-Out

The work scope shall require 100% combustion safety test-out at the end of the project of all units and CAZ(s) that were affected by the scope of work.

12.16.3.7 Construction Completion Required Repairs

All "stop-work" deficiencies according to the current BPI single family combustion safety protocols shall be repaired. All "recommended" repairs should be performed.

13 Indoor Air Quality and Ventilation

While considering recommendations to improve energy efficiency, the recommendations in the energy audit report shall strive to maintain or improve indoor air quality. The energy audit report shall specify improvements to reduce potential indoor air pollution sources and to provide adequate ventilation.

Disclaimer: While the on-site evaluation is not intended to be a health and safety assessment, a well-trained auditor with a strong foundation in building science will have an understanding of urgent health and safety problems that are commonly found in multifamily buildings. The auditor should, therefore, alert building staff to adverse conditions when they are identified. When adverse health and safety conditions are identified that are beyond the expertise of the auditor, the energy audit report should contain recommendations to consult with a qualified specialist. It is not to be expected that the energy auditor is a trained professional in any of the health and safety areas outlined in Section 13 (Indoor Air Quality and Ventilation) of this standard.

13.1 General Requirements

A comprehensive visual inspection and evaluation of the building systems that affect indoor air quality shall be completed throughout the building in accordance with the sampling procedures outlined in Section 10 (Sampling Procedure) of this standard. During the on-site evaluation, the auditor shall:

13.1.1 Identify System(s)

Identify dwelling unit, common area, and whole building ventilation system types, locations, operation specifications, usage/time schedules, filter replacement schedules and actual performance. If ventilation systems are in individual apartments rather than centrally located, the auditor shall sample in accordance with Section 10 (Sampling Procedure) of this standard.

13.1.2 Create an Equipment Schedule

Create an equipment schedule of all fans (including exhaust, supply, energy recovery ventilators, and heat recovery ventilators), motors, mufflers, coils/heat exchangers, dampers, ductwork and all accessible connection points associated with the ventilation system. This schedule shall be included in the energy audit report.

13.1.3 Visually Evaluate System

Where feasible, visually inspect for dirt, leakage, obstructions and effective system operation. The results of this evaluation shall be included in the energy audit report.

13.1.4 Review Operations and Maintenance Procedures

Interview building maintenance staff to document the existing routine maintenance performed on ventilation equipment, including historical repairs or ongoing issues.

13.1.5 Pollution Sources

Identify sources of potential indoor air pollution for the owners and occupants. The energy audit report and cost-benefit analysis should prioritize removal of pollution sources first, followed by pollutant-source isolation, and then ventilation improvements.

13.1.6 Moisture

Visually inspect for signs of moisture in accordance with Section 11 (Moisture Control) of this standard.

13.1.7 Outdoor Air Intakes

Inspect existing ventilation outdoor air intakes. The auditor shall document location, size, and determine if intake air source is at risk of contamination from pollutant sources (parking garages, combustion sources, refuse areas, etc.). The auditor shall make recommendations for improvements to placement, location, and/or design of ventilation air intakes to ensure an adequate supply of fresh air to the system. The auditor shall ensure proper closure of all outdoor air intake dampers.

13.1.8 Make-Up Air for Exhaust Systems

Evaluate sources of make-up air for exhaust systems. The auditor shall identify make-up air sources and shall evaluate make-up air delivery systems for proper performance. Airflow rates shall be in accordance with all applicable code requirements and/or the most current version of *ANSI/ASHRAE 62.2-2013 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings.* Where deficiencies in make-up airflow are identified, recommendations for improvements shall be made in the energy audit report.

13.1.8.1 Compartmentalization

If measures have been taken or recommended to minimize air movement across interior envelope components (compartmentalization), the auditor shall verify that adequate make-up air is provided to the space. Where no dedicated make-up air system exists, the auditor shall assess the need for a dedicated make-up air system and shall document recommendations in the energy audit report.

13.1.9 Filtration Material

The auditor shall visually inspect condition and type of existing filtration material located on air intakes and within make-up air handlers. The auditor shall make recommendations for improvements to filtration replacement schedule, filter quality, filter size, and filter bypass opportunities as necessary to ensure supply air is properly filtered.

13.1.10 Heating and Cooling Coils

The auditor shall visually inspect condition of heating and cooling coils and ensure that all heating and cooling coils are clean and allow for adequate airflow. If coils are not easily accessible for inspection, the energy audit report should contain recommendations for the property owner to consult with a qualified HVAC specialist to conduct inspection.

13.1.11 Openings to the Outside

The auditor shall visually inspect all openings to the outside greater than ¼ inch. The auditor shall make recommendations for a rodent/corrosion-proof screen across identified openings.

13.2 Measurement of Flow Rates

The auditor shall document the measured flow rate of exhaust and supply registers in the units and common areas, and at the outdoor terminations in accordance with Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) *HVAC Systems - Testing, Adjusting and Balancing*

or

ANSI/ACCA[i] *5* QI-2010-*HVAC Quality Installation Specification*

or

ANSI/ASHRAE *Standard 111-2008, Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems*

All sampling shall be performed in accordance with Section 10 (Sampling Procedure) of this standard.

13.2.1 Assessment Tools

Flow rates shall be measured with flow measuring hood (bolometer), rotating vane anemometer, hot wire anemometer, pitot tube with micromanometer (analog or digital) or magnehelic gauge, calibrated fans or other instrumented diagnostic tool.

13.2.2 Tool Calibration

Airflow measuring equipment shall be calibrated regularly in accordance with the manufacturer's literature.

13.2.3 Garages

The auditor shall measure garage ventilation systems (natural or mechanical) for exhaust flow rates in accordance with *ANSI/ASHRAE 62.2-2013 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, Section 8.3. The energy audit report shall recommend improvements necessary to ensure proper CO and combustion by-product removal from these spaces.

13.2.3.1 Garage Compartmentalization

The auditor shall verify that garages connected to the residential structure are isolated and compartmentalized from the rest of the structure.

13.2.3.2 Demand-Based Ventilation

Auditor shall assess the opportunity for demand-based ventilation controls in garages and shall make recommendations for such controls when feasible.

13.2.3.3 Carbon Monoxide

Auditor shall measure CO levels per section 12.14.

13.3 Duct Leakage Testing

Where the auditor recommends duct sealing as an ECM or health and safety recommendation, the energy audit report shall provide documented evidence that duct leakage was assessed during the on-site evaluation.

13.3.1 Assessment Tools

The auditor shall identify duct leakage sites through visual inspection and/or using industry-approved diagnostic tools such as boroscopes, remote cameras, infrared thermography, smoke, and/or pressure tests (ASTM *E1186-03 (2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems*).

13.4 Fan Assessment

The auditor should assess general fan condition and alignment of belts, sheaves, and pulley. Excessive fan noise or movement/shaking of fan housing should be noted in the energy audit report. The auditor shall sample in accordance with Section 10 (Sampling Procedure) of this standard.

13.4.1 Rotation in Centrifugal Fans

When feasible, the auditor should inspect centrifugal fans for proper wheel rotation by momentarily energizing the fan. Rotation should correspond with rotational decal that can be found on most fans.

13.4.2 Fan Motor

Where appropriate, the auditor shall evaluate efficiency opportunities in replacing fan motors with premium efficiency motors and/or advanced fan controls. When making recommendations to replace motor or add controls, the auditor shall evaluate existing distribution system and static pressure.

13.5 Ventilation Control Assessment

Existing ventilation controls shall be visually inspected during the on-site evaluation in accordance with the sampling procedures outlined in Section 10 (Sampling Procedure) of this standard.

13.5.1 Occupancy-Based

The auditor shall visually verify all sensor locations and ensure that they are properly located. The auditor shall verify that the occupancy controls activate and de-activate the fans as intended by the designer or controls manufacturer.

13.5.2 Timer-Based

The auditor shall verify that clocks on timer-based controls reflect the actual time of day, pins on mechanical timers are properly set, and control strategies (on/off times) are optimized and set in accordance with local codes and standards.

13.5.3 Demand-Based

The energy audit report shall recommend that existing CO^2 demand-controlled ventilation systems be calibrated by an approved professional every year, or in accordance with manufacturer's recommendations.

13.5.4 Garage Ventilation Controls

Where ventilation controls exist, the auditor shall visually inspect controls and verify control set-points are appropriate for site-specific conditions.

13.5.5 Ventilation Control Recommendations

Where opportunities are identified the energy audit report shall provide recommend-ations for improving, repairing, or optimizing existing controls and set-points. Where opportunities are identified, the energy audit report shall provide recommendations for installing new controls.

13.6 Energy Audit Report

Based on the results of the on-site evaluation, the energy audit report shall include the following:

13.6.1 Existing Ventilation Performance

A thorough description and written evaluation of the existing ventilation system, including all documentation and diagnostic results shall be assembled by the auditor during the pre-site visit and on-site assessment. Where existing health and safety issues or ECMs are identified, the energy audit report shall include a detailed description of each proposed measure.

13.6.2 Reporting of Ventilation Rates

The energy audit report shall document flow measurements, any distribution imbalances that are identified, ventilation strategy (continuous, timed, intermittent), outdoor conditions (temperature, prevailing wind speed and direction) and whether windows in the building are open or closed.

13.6.3 Evaluate Improvements or Replacements

If measured exhaust and/or supply rates are determined to be deficient, the energy audit report shall include recommendations to increase flow rates, balance distribution and/or reduce duct leakage in order to promote proper indoor air quality. If measured exhaust and/or supply rates are determined to be excessive the energy audit report shall include recommendations to decrease flow rates, in order to improve efficiency. Fan flow testing should be performed in order accurately quantify energy savings opportunities from flow rate reductions.

13.6.4 Report Recommendations and IAQ

The auditor should ensure that no energy efficiency recommendations are made that pose the threat of exacerbating any existing indoor air quality (IAQ) issues, for example, introducing makeup air into a space that has friable asbestos present.

14 Building Enclosure Performance

The on-site evaluation shall include an evaluation of the performance of all component assemblies of the building enclosure for insulation, moisture control, air leakage and general conditions. The energy audit report shall include recommendations for upgrades as appropriate.

14.1 General Requirements

During the on-site evaluation, the auditor shall:

14.1.1 Areas to Evaluate

Visually evaluate the following components: walls, floors, crawlspaces, basements, roofs, attics, ceilings, windows, doors, ventilation openings, thermal bypasses, etc. The auditor shall sample in accordance with Section 10 (Sampling Procedure) of this standard.

14.1.1.1 Inaccessible Areas

For inaccessible areas such as walls and flat roof assemblies, the auditor should use a reasonable level of effort to determine existing assembly construction through the use of industry approved tools and techniques, such as boroscopes, infrared thermography, removal of access panels, probing, etc.

14.1.1.2 Invasive Inspections

If the auditor chooses to perform invasive inspections of the building assemblies, this shall be discussed and approved by building management prior to performing inspection.

14.1.2 Evaluate Ventilation

Evaluate existing ventilation (passive and mechanical) in all locations defined in Section 14.1.1 (Building Enclosure Performance - Areas to Evaluate) for existing performance and deficiencies. Based on this evaluation the energy audit report shall include

recommended improvements or alterations to achieve energy savings, maintain building durability, or as necessary as part of an insulation retrofit measure.

14.1.3 Window and Door Performance

Evaluate window and door performance and fit by testing operation. Window and doors shall be evaluated visually for air leaks, condition of weather-stripping and other hardware, and movement of window when closed and latched.

14.1.4 Evaluate Building Enclosure Air Leakage

Evaluate air leakage through the building enclosure as a result of stack effect, wind effect, mechanical systems, bypasses, and other mechanisms (stairwells, elevator shafts, open skylights or windows, dampers, mechanical and/or plumbing shafts, garbage chutes etc.). The evaluation shall include visual observations, and should include either qualitative or quantitative testing per below:

14.1.4.1 Qualitative Testing

The auditor should use qualitative observations such as zonal pressure readings (manometer), air current testers (smoke), infrared thermography, etc. to evaluate envelope leakage and enclosure performance.

14.1.4.2 Quantitative Testing

The auditor should use quantitative testing such as calibrated, induced pressure tests to evaluate envelope leakage and enclosure performance. Reference

14.1.4.2.1 Whole Building Testing

When whole building blower door testing is performed, it shall be performed to ASTM *E779-10 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*.

14.1.4.2.2 Localized Unit Testing

When localized dwelling unit blower door tests are performed, the auditor shall take steps to quantify or nullify measured leakage between dwelling units vs. leakage to outside if test results will be used to estimate energy savings from air sealing measures. “Unguarded” localized dwelling unit blower door tests can be performed when the results are used to assess the compartmentalization of the dwelling unit. When localized unit blower door testing is performed, it shall be performed to ASTM *E779-10 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*.

14.1.4.3 Testing Methodology

When air leakage testing is performed, the auditor shall document testing methodology, building "set-up," site, weather conditions, and testing results, such that testing and findings can be verified by a third party when necessary.

14.1.4.4 Visible Air Leaks

Where visible air leakage pathways are identified during the on-site evaluation of the building enclosure, the energy audit report shall recommend durable and airtight air seals.

14.1.5 Thermal and Air Barrier System

Where possible, the auditor shall verify that the thermal and air barriers are continuous and properly aligned. Deficiencies in these systems should be documented in the energy audit report, and recommendations to address identified issues shall be included in the cost-benefit analysis.

14.2 Energy Audit Report

Based on the results of the on-site evaluation, the energy audit report shall include the following:

14.2.1 Existing Enclosure Performance

Estimated R-values of opaque building assemblies and estimation of U-factors and solar heat gain coefficients (SHGCs) of windows and doors.

14.2.1.1 Assumptions

Any assumptions, including de-rating of poorly performing assemblies/insulation, shall be documented in the energy audit report. In cases where the auditor was not able to verify a building component during the on-site evaluation, the auditor shall include plans, history of building construction, or other means, and disclose the source of information in the energy audit report.

14.2.1.2 Insulation Retrofits

Where applicable, the auditor shall include in the cost-benefit analysis an evaluation of insulation retrofits for feasibility, energy savings and hygrothermal impact.

14.2.1.3 Shading and Reflectivity Retrofits

Where applicable, the auditor shall include in the cost- benefit analysis an evaluation of the feasibility and energy impact of shading and solar-reflectance retrofits for the windows, roof and walls. Evaluate proposed changes for hygrothermal issues.

14.2.1.4 Windows and Door Retrofits

Where applicable, the auditor shall include in the cost-benefit analysis an evaluation of the feasibility and energy savings for window and/or door treatments (such as shades, window films etc), including window and/or door replacements for improvements in thermal performance and/or shading. The auditor shall evaluate proposed changes for hygrothermal issues.

14.2.1.5 Air Sealing Retrofits

Where applicable, the auditor shall include in the cost-benefit analysis an evaluation of air sealing retrofits for feasibility, energy savings and hygrothermal impact.

14.2.1.5.1 Prioritization of Air Sealing

The auditor should recommend prioritization of individual air sealing measures in building based on impact/cost effectiveness of those measures. When less cost effective air sealing measures are prioritized, the auditor shall clearly disclose rationale behind the decision to prioritize these locations (such as associated non-energy benefits).

14.2.2 Durability Requirements

Where deficiencies are found during the on-site evaluation, including any moisture related issues in Section 11 (Moisture Control) of this standard that may affect the full useful life of a proposed measure; the energy audit report shall include necessary corrective measures to address the deficiency.

14.2.3 Staging of Work

Where enclosure air-sealing work is suggested in the energy audit report, the auditor should recommend that work be performed in conjunction with insulation work, and that air sealing occur prior to or at the same time as the insulation work (unless insulation is considered to be an air barrier once installed).

14.2.4 Non-Energy Benefits

Where applicable, the auditor shall indicate in the energy audit report additional non-energy benefits of ECMs such as occupant comfort, odor control, pest control, etc.

14.2.5 Ventilation Requirements

When making recommendations to air seal or insulate the building enclosure, the auditor shall make ventilation recommendations as needed in accordance with Section 13 (Indoor Air Quality and Ventilation) of this standard.

14.2.6 Combustion Safety Requirements

When making recommendations to air seal or insulate the building enclosure, or otherwise alter the pressure dynamics of a combustion appliance zone, the auditor shall recommend combustion safety testing to be performed in accordance with Section 12 (Combustion Appliance Testing) of this standard.

15 Domestic Hot Water

The domestic hot water system(s) (DHW) shall be identified during the on-site evaluation, documented in the energy audit report, and the energy audit report shall recommend upgrades as appropriate.

15.1 General Requirements

During the on-site evaluation, the auditor shall:

15.1.1 Identify System(s)

Identify the DHW system(s) and document all relevant information, including: central or distributed, type of equipment, controls, input/output capacity, storage volume, operating conditions, and any atypical end users (e.g., community kitchens). If DHW systems are in individual apartments rather than centrally located, the auditor shall sample in accordance with Section 10 (Sampling Procedure) of this standard.

15.1.2 Create an Equipment Schedule

Create an equipment schedule for central and in-unit DHW systems including: rated capacity, storage volume, location, and units/areas served where feasible. For in-unit and small central DHW systems, identify the unit's Energy Factor. For larger systems without an Energy Factor, identify the unit's rated thermal efficiency. When available, identify the equipment's recovery capacity and/or first hour rating. This schedule shall be included in the energy audit report.

15.1.3 Create System Schematic

Where appropriate, the auditor shall diagram the existing system to determine if as-built conditions are in accordance with manufacturer recommendations/best practices to achieve rated system efficiencies.

15.1.4 Review Operations and Maintenance Procedures

The auditor shall interview building maintenance staff to document the existing routine maintenance performed on heating equipment, including historical repairs or ongoing issues.

15.1.4.1 Maintenance Logs

The auditor shall collect maintenance log information for DHW equipment when available and shall review for recurring maintenance issues and identification of maintenance opportunities, including system leaks and/or replacement of anode rods.

15.1.5 Assess System Effectiveness

The auditor shall interview building staff and/or residents to determine if DHW temperature imbalances, other comfort complaints, or scalding risks exist.

15.1.6 Observe a Water Heating Cycle

The auditor shall observe, for a minimum of one operating cycle, the equipment and control functions to verify proper performance, as hot water demand conditions permit.

15.1.7 Verify Controls, Setpoints, and System Diagnostics

The auditor shall document system controls and setpoints. Where applicable, the energy audit report shall provide recommendations for control optimization.

15.1.7.1 Gauge Temperatures

In addition to setpoints (i.e., controls), the auditor shall document water temperatures when relevant gauges are present during water heating cycle and shall ensure that these setpoints are appropriate. This includes at supply to building, return piping, and storage tanks, when present.

15.1.7.2 Sequence of Operations

The auditor shall document sequence of operations.

15.1.7.3 Interconnected Systems

The auditor shall confirm appropriate operations with heating system when interconnected.

15.1.8 Verify System Integrity

The auditor shall evaluate the integrity/durability of the DHW system and document deficiencies in the energy audit report. Where deficiencies are found the auditor shall include necessary corrective measures to ensure the full useful life of proposed measures and ECMs for that system.

15.1.9 Combustion Safety Testing and Venting

The auditor shall complete combustion safety testing per Section 12 (Combustion Appliance and Fuel Distribution System Testing) of this standard.

15.1.10 Evaluate Potential Health and Safety Issues

The auditor shall evaluate existing health and safety issues in the DHW system in accordance with Section 2 (Health and Safety Related Requirements) of this standard.

15.1.11 Combustion Efficiency Testing

Combustion efficiency tests shall be completed at steady-state conditions and interpreted based on observed operating conditions to establish overall equipment efficiency.

15.2 Distribution Systems

During the on-site evaluation, the auditor shall:

15.2.1 Fixture Water Temperatures

Measure and record hot water temperatures at a sample of points of use in units and common areas. Sampling shall be performed in accordance with Section 10 (Sampling Procedure) of this standard. Temperatures higher than 120°F at the unit taps shall be recommended for adjustment resulting in temperature turn-down.

15.2.2 Time for Hot Water

The auditor shall measure and record the time for hot water to reach taps. If the auditor observes a long delay in delivery of hot water, further distribution improvements should be recommended.

15.2.3 Recirculation Pump(s)

The auditor shall identify, when existing, the recirculation pump/motor model, horsepower, controls, setpoints, and sequence of operations. The auditor should evaluate energy savings for recirculation pump and/or control system adjustment or replacement, when feasible.

15.2.4 Pipe and Tank Insulation

The auditor shall document condition, thickness, and type of existing pipe and storage tank insulation. Recommendations for improvements to insulation should reference the following table or local code, whichever is more stringent.

15.2.4.1 Table 6.8.3A, Minimum Pipe Insulation Thickness (from ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings*)[3]

TABLE 6.8.3A Minimum Pipe Insulation Thickness
Heating and Hot Water Systems[a,b,c,d]
(Steam, Steam Condensate, Hot Water Heating and Domestic Water Systems)

Fluid Operating Temperature Range (°F) and Usage	Insulation Conductivity		Nominal Pipe or Tube Size (in)				
	Conductivity Btu·in./(h·ft²·°F)	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness (in)				
>350 °F	0.32–0.34	250	4.5	5.0	5.0	5.0	5.0
251°F–350°F	0.29–0.32	200	3.0	4.0	4.5	4.5	4.5
201°F–250°F	0.27–0.30	150	2.5	2.5	2.5	3.0	3.0
141°F–200°F	0.25–0.29	125	1.5	1.5	2.0	2.0	2.0
105°F–140°F	0.22–0.28	100	1.0	1.0	1.5	1.5	1.5

a For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$ where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in./h·ft2·°F); and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b These thicknesses are based on energy *efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

c For piping smaller than 1½" and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1" shall be permitted (before thickness adjustment required in footnote a) but not to thicknesses below 1".

d For direct-buried heating and hot water *system* piping, reduction of these thicknesses by 1.5" shall be permitted (before thickness adjustment required in footnote a) but not to thicknesses below 1".

e The table is based on steel pipe. Non-metallic pipes schedule 80 thickness or less shall use the table values. For other non-metallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

[3] ©ASHRAE (*ANSI/ASHRAE/IES Standard 90.1-2010), (Energy Standard for Buildings Except Low-Rise Residential Buildings*), (Section 6.8 Minimum Equipment Efficiency Tables), (Table 6.8.3A)

15.2.5 Flow Measurements

The auditor shall measure and record flow rates at DHW end use fixtures, including at showers and faucets. Sampling shall be performed in accordance with Section 10 (Sampling Procedure) of this standard.

15.2.5.1 High Flow Fixtures

The energy audit report should include a recommendation of appropriate replacements or alternatives to high-flow fixtures.

15.2.5.2 Tub Diverters

The auditor should visually inspect tub diverters and identify any significant leaks. Where leaks are identified, they should be clearly documented in the energy audit report, and the auditor should recommend that leaks be repaired as a part of the work scope.

15.3 Energy Audit Report

Based on the results of the on-site evaluation, the energy audit report shall include the following:

15.3.1 Existing Domestic Hot Water Performance

A thorough description and written evaluation of the existing domestic hot water system, including all documentation and diagnostic results assembled by the auditor during the pre-site visit and on-site assessment. Where existing health and safety issues or ECMs are identified, the energy audit report shall include a detailed description of each proposed measure.

15.3.2 Evaluate Improvements or Replacements

The energy audit report shall evaluate improvements and/or replacement of DHW system equipment (including all water heater/boiler, circulation pumps, controls, storage tanks, insulation, etc.) based on system usage, operation, and rated and/or measured combustion efficiencies.

15.3.2.1 Equipment and Material Information

When recommending improvements or replacements, the recommendation should be specific enough to ensure that projected savings are realized with implementation, including equipment and material information used to model projected savings, control strategies, setpoints, etc.

15.3.2.2 Sized for Loads

When recommending replacement of DHW systems, they shall be designed and sized for design loads in accordance with manufacturers' published sizing guidelines or generally accepted engineering standards.

16 Heating Systems

The heating system(s) shall be identified during the on-site evaluation, documented in the energy audit report, and the energy audit report shall recommend upgrades as appropriate.

16.1 General Requirements

During the on-site evaluation, the auditor shall:

16.1.1 Identify System(s)

Identify the heating system(s) and document all relevant information, including: central vs. distributed, common area or other local packaged units, type of equipment, controls, nameplate efficiency, and operating conditions. If heating systems are in individual apartments rather than centrally located, the auditor shall sample in accordance with Section 10 (Sampling Procedure) of this standard.

16.1.2 Create an Equipment Schedule

Create an equipment schedule for central and in-unit systems including: rated capacity, location, and units/areas served where feasible. This schedule shall be included in the energy audit report.

16.1.3 Create System Schematic

Where appropriate, the auditor shall diagram the existing system to determine if as-built conditions are in accordance with manufacturer recommendations/best practices to achieve rated system efficiencies.

16.1.4 Review Operations and Maintenance Procedures

Interview building maintenance staff to document the existing routine maintenance performed on heating equipment, including historical repairs or ongoing issues.

16.1.4.1 Maintenance Logs

The auditor shall collect maintenance log information for heating equipment when available and shall review for recurring maintenance issues and identification of maintenance opportunities.

16.1.5 Assess System Effectiveness

Interview building staff and/or residents to determine if temperature imbalances or other comfort complaints exist.

16.1.6 Observe a Heating Cycle

Observe, for a minimum of one operating cycle, the equipment and control functions to verify proper performance, as weather conditions permit.

16.1.7 Verify Controls, Setpoints, and System Diagnostics

Document system controls and setpoints such as temperature, pressure, schedules, outdoor reset, etc. and ensure that these setpoints and sensing locations are appropriate.

16.1.7.1 Gauge Settings

In addition to setpoints (i.e., controls), the auditor shall document supply/return temperatures and system pressures when relevant gauges are present during heating cycle and shall ensure that these setpoints are appropriate.

16.1.7.2 Sequence of Operations

The auditor shall document sequence of operations.

16.1.7.3 Control Optimization

The auditor shall provide recommendations for controls optimization and where appropriate shall include an evaluation of Building Management System (BMS)/Energy Management System (EMS) systems in the cost-benefit analysis.

16.1.7.4 Commissioning

The auditor shall provide recommendations for system commissioning/retro-commissioning (Cx/RCx) where appropriate.

16.1.7.5 Heating and Cooling Controls

When both heating and cooling systems exist in the building, the auditor shall document the existing controls used to alternate between system operation and ensure that setpoints are appropriate.

16.1.8 Verify System Integrity

The auditor shall evaluate the integrity/durability of the heating system and document deficiencies in the energy audit report. Where deficiencies are found the auditor shall include necessary corrective measures to ensure the rated useful life of the equipment.

16.1.9 Perform Combustion Safety Testing

The auditor shall complete combustion safety testing per Section 12 (Combustion Appliance and Fuel Distribution System Testing) of this standard.

16.1.10 Evaluate Potential Health and Safety Issues

The auditor shall evaluate existing health and safety issues in heating system in accordance with Section 2 (Health and Safety Related Requirements) of this standard.

16.1.11 Combustion Efficiency Testing

Combustion efficiency tests shall be completed at steady-state conditions and interpreted based on observed operating conditions to establish overall equipment efficiency.

16.1.11.1 Modulating Equipment

For modulating equipment combustion efficiency should be completed at multiple firing rates when possible.

16.1.11.2 Water Meters

The auditor should recommend the installation of water meters on all feed tanks, condensate receivers, and other boiler fill devices (where not currently installed) to allow maintenance staff to monitor and diagnose system leaks.

16.2 Steam Systems

For buildings that have steam systems, the auditor shall verify the following:

16.2.1 Water Level

Boiler water in the system is at the correct level, and that there are no complaints of water hammer or heating imbalance in the system.

16.2.2 Feed Tanks and Condensate Receivers

All feed tanks and condensate receivers are working properly and are insulated. Recommendations for improvements to pipe insulation should reference ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings*, Table 6.8.3A (See Section 15.2.4.1 of this standard) or local code, whichever is more stringent.

16.2.3 Steam Leaks

That there are no steam leaks at the boiler or within distribution system through visual inspection, verification of water meter logs, thermography, or other means.

16.2.4 Pipe Insulation

The auditor shall document condition, thickness, and type of existing pipe insulation. Recommendations for improvements to pipe insulation should reference ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings, Table 6.8.3A* (See Section 15.2.4.1 of this standard) or local code, whichever is more stringent

16.2.5 Chemical Treatment

That boiler feedwater chemical treatment system is installed where appropriate and maintaining appropriate system pH levels.

16.2.6 District Steam

Where buildings are served by district steam (or other source off site), the auditor shall also address the following items:

16.2.6.1 Condensate

If condensate currently drains to sewer, the auditor shall evaluate opportunities for domestic hot water pre-heat or other forms of heat recovery from condensate.

16.2.6.2 Primary Steam Valve

Identify and locate the primary steam valve and ensure that controls are modulating the valve as intended by the design.

16.2.6.3 Insulation

Ensure that all high, medium, and low pressure steam lines and all pressure reducing valves are insulated in accordance with local codes (based on operating pressures and temperatures).

16.2.7 Steam Traps, Air Vents, Thermostatic Radiator Valves, and Emitters

During sampling of units and for all accessible main supply and return lines, the auditor shall verify that steam traps, air vents, thermostatic radiator valves (TRVs), heat emitters (radiators, fan coils, etc), are properly installed and in working order.

16.2.7.1 Maintenance

The auditor should determine the frequency of existing radiator and main steam trap maintenance and make recommendations to increase frequency as appropriate.

16.2.7.2 Balancing Issues

If steam balancing issues are identified, recommendations for venting improvements should be evaluated.

16.3 Hydronic (Hot Water) Systems

For buildings that have hydronic systems, the auditor shall verify the following:

16.3.1 Expansion & Compression Tank(s)

The auditor shall determine if the existing tank is a bladder type expansion tank or a compression tank. Based on this determination the auditor shall verify that it is performing properly based on its type, is properly located in system, and is not waterlogged.

16.3.2 Air and Sediment Removal Systems

That proper air elimination and sediment removal systems are installed and working.

16.3.3 Circulators

That all heating system circulators are sized, piped, and controlled properly. Where appropriate and cost effective, auditor should address the feasibility of upgrades to circulators including:

- Reduction in circulator size or impeller trim when existing is oversized,
- Replacement with more efficient motor/pump (e.g., National Electrical Manufacturers Association (NEMA) premium efficiency rated, electronically commutated (EC) motor, etc.),
- Variable-frequency drive (VFD) control of circulator in conjunction with removal of bypass/pressure reducing valves (PRVs) and installation of primary secondary piping (when necessary),
- Correction or addition of controls to provide appropriate pump sequencing.

16.3.4 Distribution Valves, TRVs, and Emitters

During sampling of units and for all accessible main supply and return lines, the auditor shall verify that thermostatic valves, balancing valves, heat emitters (radiators, fan coils, etc), and other thermostatic or flow controls are properly installed and in working order.

16.3.5 Chemical Treatment

For information on chemical treatment see Section 16.2.7 (Heating Systems - Chemical Treatment) of this standard.

16.3.6 Water Leaks

That there are no water leaks at the boiler/heating equipment or within distribution system through visual inspection, verification of water meter logs, thermography, or other means.

16.3.7 Pipe Insulation

The auditor shall document condition, thickness, and type of existing pipe insulation. Recommendations for improvements to pipe insulation should reference ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings*, Table 6.8.3A (See Section 15.2.4.1 of this standard) or local code, whichever is more stringent.

16.4 Forced Air Systems

For buildings that have forced air systems, the auditor shall:

16.4.1 Recommend Improvements

When recommending improvements to a forced air system the auditor shall reference BPI Heating Professional Standard. Additionally, the auditor shall:

16.4.2 Evaluate Filter Effectiveness

Evaluate opportunities to improve filtration and system performance and shall document type, size, location in system, evidence of air being bypassed or contamination (leakage around access panels, etc), frequency of filter changes, pressure drop readings where appropriate.

16.4.3 Evaluate Duct Sizing

When system performance issues are identified during the evaluation, existing duct sizing should be evaluated based on existing equipment size and ANSI/ACCA *Manual D - Residential Duct Systems* (or comparable calculation methodology) and appropriate recommendations made to correct sizing.

16.4.4 System Construction

The auditor shall evaluate and document the type of duct materials used in system, visually check a sampling of duct connection details (where accessible) to determine sealing methodology, and evaluate system for efficient layout and proper support.

16.4.5 Static Pressure and Temperature Rise

The auditor shall measure static pressure and temperature rise in accordance with the BPI Heating Professional Standard, compare against manufacturer nameplate requirements, and make recommendations per BPI Heating Professional Standard.

16.4.6 System Flow

The auditor shall measure system flow at system supply and intake locations and shall make recommendations as necessary to provide appropriate flow to each zone of the building. When making recommendations the auditor shall reference ANSI/ACCA

Manual J Residential Load Calculation and *Manual D Residential Duct Systems* or comparable calculation methodologies.

16.4.7 Duct Location

The auditor shall evaluate duct location and impact on system operation. The auditor shall document percentage of ductwork located within/outside thermal envelope.

16.4.8 Duct Insulation

The auditor shall document condition, thickness, and type of existing duct insulation. Recommendations for improvements to insulation should reference the following table or local code, whichever is more stringent.

16.4.8.1 Table 6.8.2A Minimum Duct Insulation R-Value, Cooling and Heating Only Supply Ducts and Return Ducts (from ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings)*[4]

6.8.2 Duct Insulation Tables

TABLE 6.8.2A Minimum Duct Insulation R-Value,[a] Cooling and Heating Only Supply Ducts and Return Ducts

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with Roof Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Heating-Only Ducts							
1, 2	none	none	none	none	none	none	none
3	R-3.5	none	none	none	none	none	none
4	R-3.5	none	none	none	none	none	none
5	R-6	R-3.5	none	none	none	none	R-3.5
6	R-6	R-6	R-3.5	none	none	none	R-3.5
7	R-8	R-6	R-6	none	R-3.5	none	R-3.5
8	R-8	R-8	R-6	none	R-6	none	R-6
Cooling-Only Ducts							
1	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-1.9	none	none
4	R-3.5	R-3.5	R-6	R-1.9	R-1.9	none	none
5, 6	R-3.5	R-1.9	R-3.5	R-1.9	R-1.9	none	none
7, 8	R-1.9	R-1.9	R-1.9	R-1.9	R-1.9	none	none
Return Ducts							
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none

[a] Insulation R-values, measured in (h·ft^2·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior *walls* are used as *plenum walls*, *wall* insulation shall be as required by the most restrictive condition of Section 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a *mean temperature* of 75°F at the installed thickness.
[b] Includes crawlspaces, both ventilated and nonventilated.
[c] Includes return air *plenums* with or without exposed *roofs* above.

[4] ©ASHRAE (*ANSI/ASHRAE/IES Standard 90.1-2010), (Energy Standard for Buildings Except Low-Rise Residential Buildings*), (Section 6.8 Minimum Equipment Efficiency Tables), (Table 6.8.2A)

16.4.9 Duct Leakage

Where the auditor recommends duct sealing as an ECM or health and safety recommendation, the energy audit report shall provide documented evidence that duct leakage was assessed during the on-site evaluation.

16.4.9.1 Identification of Duct Leakage Areas

The auditor shall identify duct leakage sites through visual inspection or using industry approved tools such as infrared thermography, smoke, and/or pressure tests.

16.4.9.2 Quantifying Duct Leakage

When quantifying duct leakage, an appropriate type of measurement system shall be used, which includes a metered and calibrated duct pressurization device.

16.4.9.2.1 Pre-and Post- Duct Leakage

Pre- and post-installation duct leakage shall be measured any time that duct sealing is part of the work scope to verify the success of the installation. Duct leakage areas shall be diagnosed using appropriate duct leakage testing equipment and/or pressure pan tests to prioritize leakage areas (treating the largest leaks and the highest pressure areas first) anytime duct sealing is installed.

16.4.10 Ventilation

Where forced air systems also supply ventilation air, refer to Section 13 (Indoor Air Quality and Ventilation) of this standard for requirements.

16.4.11 Fan Motor

Where appropriate, the auditor shall evaluate efficiency opportunities in replacing blower motor with premium efficiency motors or advanced fan controls. When making recommendations to replace blower motor or add controls, the auditor shall evaluate existing distribution system and static pressure.

16.5 Other Heating Systems

For buildings with heating systems that are not represented above, the auditor shall evaluate the system in accordance with all applicable sections in Section 16.1 (Heating Systems - Steam Systems). Distribution system and unitary equipment shall be evaluated based on all applicable points in 16.2 - 16.4.

16.6 Beyond Auditor Expertise

If system evaluation or identification of potential ECMs are beyond the expertise of the auditor, the auditor shall retain the services of a qualified specialist as necessary to properly evaluate the system.

16.7 Energy Audit Report

Based on the results of the on-site evaluation, the energy audit report shall include the following:

16.7.1 Existing Domestic Hot Water Performance

A thorough description and written evaluation of the existing heating system, including all documentation and diagnostic results assembled by the auditor during the pre-site visit and on-site assessment. Where existing health and safety issues or ECMs are identified, the energy audit report shall include a detailed description of each proposed measure.

16.7.2 Evaluate Improvements or Replacements

The energy audit report shall evaluate improvements and/or replacement of heating system equipment (including all heating systems, circulation pumps, ducts, filters, controls, etc.) based on system usage, operation, and rated, part-load, and/or measured combustion efficiencies.

16.7.2.1 Compatibility with Existing Systems

When replacement equipment is recommended, the auditor shall verify that recommended equipment is compatible with existing system, and that replacement equipment is capable of achieving rated (or projected) efficiency in that system (e.g., condensing boiler will not achieve rated thermal efficiency in a high temperature distribution system).

16.7.2.2 Equipment and Material Information

When recommending improvements or replacements, the recommendation should be specific enough to ensure that projected savings are realized with implementation, including equipment and material information used to model projected savings, control strategies, setpoints, etc.

16.7.2.3 Technology and Fuel Switching

Where appropriate, the auditor shall evaluate the cost effectiveness of heating equipment replacement with different heating technology. (electric resistance or gas to heat pump, steam to hot water, etc.)

16.7.2.4 Sized for Loads

When recommending replacement of heating systems, recommendations shall include proper sizing of new equipment based on actual heating load calculations for the building. Acceptable sizing calculation methods include ACCA *Manual J* and *Manual S*, Institute of Boiler and Radiator Manufacturers (IBR) load calculations, or other comparable calculation procedures. Replacement systems should not be sized larger than the existing system without providing a load calculation verifying the need for a larger system. Gas and electrically fueled heating systems shall be sized within 25% of calculated design loads. Oil fueled heating systems shall use the smallest available burner size that meets the calculated heating load for the building.

17 Air Conditioning

The air conditioning system(s) shall be identified during the on-site evaluation, documented in the energy audit report, and the energy audit report shall recommend upgrades as appropriate.

17.1 General Requirements

During the on-site evaluation, the auditor shall:

17.1.1 Identify System(s)

Identify the air conditioning system type(s) and document all relevant information, including: central vs. distributed, common area or other local packaged units, type of equipment, controls, nameplate efficiency, and operating conditions. If air conditioning systems are in individual apartments rather than centrally located, the auditor shall sample in accordance with Section 10 (Sampling Procedure) of this standard.

17.1.2 Create an Equipment Schedule

Create an equipment schedule for central and in-unit systems including: manufacturer and model numbers, nameplate efficiency (Seasonal Energy Efficiency Ratio (SEER)**,** Energy Efficiency Ratio (EER)**,** or Coefficient of Performance (COP)), fan motor size, fan flow rate, and rated cooling capacity (Btu/hr or tons), equipment location, and spaces or zones served. This schedule shall be included in the energy audit report.

17.1.3 Create a System Schematic

Where appropriate, the auditor shall diagram the existing system to determine if as-built conditions are in accordance with manufacturer recommendations/best practices to achieve rated system efficiencies.

17.1.4 Review Operations and Maintenance Procedures

The auditor shall interview building maintenance staff to document the existing routine maintenance performed on air conditioning equipment, including historical repairs or ongoing issues.

17.1.4.1 Maintenance Log

The auditor shall collect maintenance log information for cooling equipment when available and shall review for recurring maintenance issues and identification of maintenance opportunities.

17.1.5 Assess System Thermal Comfort Effectiveness

The auditor shall interview building staff and/or residents to determine if temperature imbalances or other comfort complaints exist.

17.1.6 Observe a Cooling Cycle

Observe, for a minimum of one operating cycle, the equipment and control functions to verify proper performance, as weather conditions permit.

17.1.7 Verify and Document Controls, Setpoints, and System Diagnostics.

Observe, for a minimum of one operating cycle, the equipment and control functions. Document system controls and setpoints, and ensure that these setpoints and sensing locations are appropriate.

17.1.7.1 Sensor Locations

The auditor shall visually verify all sensor locations, as applicable and accessible, and ensure that they are located in the proper location. Manufacturer's installation manual shall be consulted to determine recommended locations of system sensors.

17.1.7.2 Sequence of Operations

Based on observations gathered during the on-site evaluation, the auditor shall document the sequence of operations, which shall include all energy saving strategies such as equipment lock-out, economizer operation for packaged A/C and air handlers, temperature reset controls, etc.

17.1.7.3 Confirm Operating Conditions

The auditor shall document supply/return temperatures and system pressures when relevant gauges are present during the cooling cycle, and shall ensure that these setpoints are appropriate.

17.1.7.4 Energy Management System (EMS) Assessment.

If an EMS is present, the auditor shall document the type of EMS, number of system control points, location of sensors, whether the system components are controlled pneumatically or through Direct Digital Controls (DDC), and trend log capabilities and any current trends that are currently set up.

17.1.8 Pipe/Duct Insulation

Determine that air conditioning ductwork, chiller pipes, and refrigerant vapor lines are insulated in all accessible locations of the building. Where uninsulated pipes or ducts are identified, recommendations for improvements to insulation should reference the following table or local code, whichever is more stringent.

17.1.8.1 Table 6.8.3B Minimum Pipe Insulation Thickness - Cooling Systems

(from ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings*, Section 6.8 Minimum Equipment Efficiency Tables)[5]

TABLE 6.8.3B Minimum Pipe Insulation Thickness
Cooling Systems (Chilled Water, Brine, and Refrigerant)[a,b,c]

Fluid Operating Temperature Range (°F) and Usage	Insulation Conductivity		Nominal Pipe or Tube Size (in)				
	Conductivity Btu·in./(h·ft²·°F)	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness (in)				
40°F–60°F	0.21–0.27	75	0.5	0.5	1.0	1.0	1.0
<40°F	0.20–0.26	50	0.5	1.0	1.0	1.0	1.5

a For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$ where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in./h·ft2·°F); and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b These thicknesses are based on *energy efficiency* considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

c For direct-buried cooling *system* piping, insulation is not required.

d The table is based on steel pipe. Non-metallic pipes schedule 80 thickness or less shall use the table values. For other non-metallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

17.1.9 Duct Leakage

Where the auditor recommends duct sealing as an ECM or health and safety recommendation, the energy audit report shall provide documented evidence that duct leakage was assessed during the on-site evaluation.

17.1.9.1 Identification of Duct Leakage Areas

The auditor shall identify duct leakage sites through visual inspection or using industry approved tools such as infrared thermography, smoke, and/or pressure tests.

17.1.9.2 Quantifying Duct Leakage

When quantifying duct leakage, an appropriate type of measurement system shall be used, which includes a metered and calibrated duct pressurization device.

[5] ©ASHRAE (*ANSI/ASHRAE/IES Standard 90.1-2010), (Energy Standard for Buildings Except Low-Rise Residential Buildings*), (Section 6.8 Minimum Equipment Efficiency Tables), (Table 6.8.3B)

17.1.9.2.1 Pre-and Post- Duct Leakage

Pre- and post-installation duct leakage shall be measured any time that duct sealing is part of the work scope to verify the success of the installation. Duct leakage areas shall be diagnosed using appropriate duct leakage testing equipment and/or pressure pan tests to prioritize leakage areas (treating the largest leaks and the highest pressure areas first) anytime duct sealing is installed.

17.1.10 Filter Effectiveness

Opportunities to improve filtration and system performance and shall document type, size, location in system, evidence of air being bypassed or contamination (leakage around access panels, etc), frequency of filter changes, pressure drop readings where appropriate. Opportunities to improve filtration and system performance

17.1.11 Duct sizing

When system performance issues are identified during the evaluation, existing duct sizing should be evaluated based on existing equipment size and ACCA *Manual D* (or comparable calculation methodology) and appropriate recommendations made to correct sizing.

17.1.12 Duct Location

Auditor shall evaluate duct location and impact on system operation. The auditor shall document percentage of ductwork located within/outside thermal envelope.

17.1.13 System Construction

The auditor shall evaluate and document the type of duct materials used in system, and visually check a sampling of duct connection details (where accessible) to determine sealing methodology, and evaluate system for efficient layout and proper support.

17.1.14 System Flow

The auditor shall measure system flow at system supply and intake locations and shall make recommendations as necessary to provide appropriate flow to each zone of the building. When making recommendations the auditor shall reference ACCA *Manual J and Manual D* or comparable calculation methodologies.

17.2 Split System Air Conditioner

For buildings that have split air conditioning systems, the auditor shall evaluate the following:

17.2.1 Condenser Coil

Verify that the condenser coil is clean and not damaged. Where deficiencies are found, the energy audit report shall include recommendations to clean or repair the condenser coil.

17.2.2 Evaporator Coil

Verify that the evaporator coil is clean and not damaged, and that the air filter is in place over the evaporator coil. Where deficiencies are found, the energy audit report shall include recommendations to clean or repair the evaporator coil.

17.2.3 Blower Motor

Verify that the blower motor belt is fastened to the fan and that it is in good condition. Where deficiencies are found, the energy audit report shall include recommendations to repair the blower motor.

17.2.4 Evaluation of Zones

Identify all zones that are served by the split system air conditioners and record all thermostat settings.

17.3 Packaged Air Conditioner Systems

For buildings that have packaged air conditioning systems, the auditor shall:

17.3.1 Condenser Coil

Verify that the condenser coil is clean and not damaged. Where deficiencies are found, the energy audit report shall include recommendations to clean or repair the condenser coil.

17.3.2 Evaporator Coil

Verify that the evaporator coil is clean and not damaged, and that the air filter is seated in place across the coil. Where deficiencies are found, the energy audit report shall include recommendations to clean or repair the evaporator coil.

17.3.3 Evaluation of Zones

Identify all zones that are served by the packaged air conditioners, document method of control, and record the thermostat settings for the zones. Where appropriate, the energy audit report should consider recommendations for integrated control systems especially designed to optimize rooftop unit (RTU) performance.

17.3.4 Diagnostic Testing

For small packaged air-conditioning systems, diagnostics should be performed depending on age and condition of systems and should be included in the following tests; fan flow, fan wattage measurements, total system power draw, refrigerant charge test, duct leakage tests, verify the economizer is working properly with an economizer functional performance test. Where deficiencies are found, the energy audit report shall include recommendations for repair of the existing cooling system (refrigerant charge, economizer repair, etc).

17.4 Packaged Terminal Air Conditioners

For buildings that have packaged terminal air conditioners and packaged terminal heat pumps, the auditor shall:

17.4.1 Visual Inspection

Visually inspect housing, connections, terminals for wear and loose connections. Where deficiencies are found, the energy audit report shall include recommendations for repair of the existing cooling system (refrigerant charge, economizer repair, etc).

17.4.2 Condenser and Evaporator Coil

Verify that the condenser and evaporator coils are clean and not damaged. Where deficiencies are found, the energy audit report shall include recommendations to clean or repair the condenser and evaporator coils.

17.5 Water Loop Heat Pumps

For buildings with water loop heat pumps, the auditor shall:

17.5.1 Outdoor Intakes

Inspect the outdoor air intake for obstructions.

17.5.2 Heat Rejection Equipment

Document the heat rejection/cooling tower equipment and operation according to Section 17.10.4 (Air Conditioning - Energy Efficiency Measures).

17.5.3 Hot Water Loop Temperatures

Verify the hot water loop temperature settings.

17.6 Fan Coil Units

For buildings that have fan coil units, the auditor shall verify the following:

17.6.1 Valves

The auditor shall visually inspect a sample number of fan coil valves and note the type and condition of the valves.

17.6.2 Coils

The auditor shall verify the coils are free of debris and appear in good condition. Finned coils should be straight and provide adequate surface area for heat exchange.

17.6.3 Energy Conservation Measures

The auditor shall make fan coil energy conservation recommendations as appropriate. Common ECMs include replacement of fan motor with more efficient electronically commutated (EC) motor, unoccupied space temperature setback, and fan coil unit scheduling.

17.7 Air Handler Units (AHUs)

For buildings that have air handling units, the auditor shall:

17.7.1 Coils

The auditor shall verify the heating and or cooling coils are free of debris and appear in good condition. Finned coils should be straight and provide adequate surface area for heat exchange.

17.7.2 Filters

The auditor shall verify that the filter bank pressure drop does not exceed design parameters.

17.7.3 Fan control

The auditor shall note if the AHU is constant speed or variable air volume (VAV). If VAV, the auditor shall also note how the fan capacity is controlled (e.g., inlet vanes, discharge dampers or VFD controls).

17.7.4 Outside Air

The auditor shall visually inspect the outside air dampers and note the minimum percent outside air for ventilation. The auditor shall visually inspect the functionality of the AHU economizer dampers, actuators and linkages, as applicable.

17.7.5 Energy Efficiency Measures

The auditor shall make AHU energy conservation recommendations as appropriate. Common ECMs include converting constant volume systems to VAV, supply air temperature reset, static pressure reset, optimize start/stop, unoccupied space temperature setback / AHU scheduling, air-side economizer retro-commissioning, optimize air-side economizer temperature lockout, and premium efficiency motors.

17.8 Chilled Water Distribution

The auditor shall note if the water distribution system is constant-flow or variable-flow and the specific flow configuration. (e.g., constant-flow with 3-way control valves, or variable-flow primary/secondary, etc.)

17.8.1 Piping Schematic

Where appropriate, the auditor shall diagram the existing chilled water piping system to help determine if as-built conditions are in accordance with best practices to achieve highest system efficiencies.

17.8.2 Energy Efficiency Measures

The auditor shall make chiller water distribution energy conservation recommendations as appropriate. Common ECMs include insulating all distribution piping and converting primary/secondary to variable primary.

17.8.3 Water Meters

The auditor should recommend the installation of water meters on all fill devices (where not currently installed) to allow maintenance staff to monitor and diagnose system leaks.

17.9 Chillers

At a minimum, the auditor shall note the following:

17.9.1 Nameplate Data

Chiller nameplate data including type and capacity.

17.9.2 Piping Configuration

Chiller piping configuration (e.g., series or parallel). The auditor should take note of chiller isolation valves or the lack thereof.

17.9.3 Chiller Sequencing

The auditor shall note if the chillers are controlled in stages, steps or by a continuous strategy.

17.9.4 Energy Efficiency Measures

The auditor shall make chiller energy conservation recommendations as appropriate. Common ECMs include high efficiency chiller replacement, high efficiency compressor retrofit, chiller sequencing optimization, installing chiller isolation valves, and chilled water temperature reset.

17.10 Cooling Towers / Heat Rejection

At a minimum, the auditor shall note the following:

17.10.1 Nameplate Data

Cooling tower / heat rejection type and capacity.

17.10.2 Cooling Tower Piping

The auditor shall note if the cooling towers are dedicated to individual chillers or if they share a common header.

17.10.3 Capacity Control

The auditor shall note how the cooling tower is controlled to maintain condenser water setpoint temperature (e.g., fan staging, variable fan speed control or variable water flow control).

17.10.4 Energy Efficiency Measures

The auditor shall make cooling tower / heat rejection energy conservation recommendations as appropriate. Common ECMs include installing variable speed control on cooling tower fans, optimizing cooling tower sequencing and condenser water temperature reset.

17.10.5 Chemical Treatment

The auditor shall conduct a visual assessment of the cooling tower to identify recommendations for improved chemical treatment as appropriate. At a minimum this would include the following:

17.10.5.1 Visual assessment of the overall condition of the cooling tower. The auditor should note excessive rusting or corrosion.

17.10.5.2 Visual inspection for excessive scaling or fouling which will reduce the effectiveness and efficiency of the heat exchange process.

17.11 Pumps (Commercial Hot Water, Chilled Water)

At a minimum, the auditor shall note the following:

17.11.1 Nameplate Data

Design gallons per minute (GPM) and head of each pump.

17.11.2 Pump configuration

The auditor shall note if the pump is dedicated or shares a common header.

17.11.3 Motor Efficiency

The auditor should determine the motor efficiency of all pumps.

17.11.4 Energy Conservation Measures

The auditor shall make pump energy conservation recommendations as appropriate. Common ECMs include premium efficiency motors, installing variable speed controls on pumps and motors. The auditor shall note if the existing motor is able to be controlled by a VFD.

17.12 Energy Audit Report

Based on the results of the on-site evaluation, the energy audit report shall include the following:

17.12.1 Existing Cooling Performance

A thorough description and written evaluation of the existing cooling system, including all documentation and diagnostic results assembled by the auditor during the pre-site visit and on-site assessment. Where existing health and safety issues or ECMs are identified, the energy audit report shall include a detailed description of each proposed measure.

17.12.2 Evaluate Improvements or Replacements

The energy audit report shall evaluate improvements and/or replacement of cooling system equipment (including all cooling systems, circulation pumps, ducts, filters, controls, etc.) based on system usage, operation, and rated, part-load, and/or measured system efficiency data.

17.12.2.1 Compatibility with Existing Systems

When replacement equipment is recommended, the auditor shall verify that recommended equipment is compatible with existing system, and that replacement equipment is capable of achieving rated (or projected) efficiency in that system.

17.12.2.2 Equipment and Material Information

When recommending improvements or replacements, the recommendation should be specific enough to ensure that projected savings are realized with implementation, including equipment and material information used to model projected savings, control strategies, setpoints, etc.

17.12.2.3 Sized for Loads

When recommending replacement of heating systems, recommendations shall include proper sizing of new equipment based on actual heating load calculations for the building. Acceptable sizing calculation methods include ACCA *Manual J* and *Manual S*, IBR load calculations, or other comparable calculation procedures. Replacement systems should not be sized larger than the existing system without providing a load calculation verifying the need for a larger system. Gas and electrically fueled heating systems shall be sized within 25% of calculated design loads.

18 Baseload Energy Efficiency

The on-site evaluation shall include an evaluation of baseload energy uses and the energy audit report shall recommend upgrades as appropriate.

18.1 General Requirements

During the on-site evaluation, the auditor shall advise owners and occupants about behavior changes that reduce energy consumption including:

18.1.1 Plug Loads

Plug loads and associated electricity costs.

18.1.1.1 Turning off Appliances

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

18.1.2 Disaggregated Base Load

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.

18.1.3 Comparative Baseload

Building baseload energy use, as compared with similar buildings in the region.

18.2 On-Site Evaluation

During the on-site evaluation, the auditor shall evaluate:

18.2.1 Kitchen Equipment

The auditor shall identify and document kitchen equipment make, model, age, and annual fuel usage. The auditor should evaluate fuel savings for replacement of existing refrigerators with ENERGY STAR® refrigerators.

18.2.2 Lighting

Existing lighting and lighting efficiency in accordance with Section 20 (Lighting) of this standard.

18.2.3 Laundry Equipment

The auditor shall identify and document laundry facility equipment make, model, and fuel type. For information on showerheads and aerators, see Section 21.4 (Water Efficiency - Washing Machines) of this standard.

18.2.4 Pools and Spas

The auditor shall identify and document nameplate data, runtimes, setpoints, and settings for all energy consuming equipment including but not limited to: heaters, circulation/filtration pump motors, controls, and pool lighting. The auditor shall identify and document pool and spa volumes and annual hours of pool and spa operation. Where applicable, the auditor shall consider improvements to the existing pool and/or spa systems, such as: multi-speed or variable speed pool pumps, pool and spa covers, improved equipment or control scheduling, pool and spa heater controls, pool and spa temperature optimization.

18.2.5 Other Baseload and Plug Loads

The auditor shall identify and document the efficiency of other major baseload energy users. High baseload uses should be identified in the energy audit report.

19 Elevators

When assessing elevator systems, the auditor shall adhere to the following requirements:

19.1 General Requirements

During the on-site evaluation, the auditor shall:

19.1.1 Type of Elevator Equipment

Visually identify, for inclusion in the energy audit report, whether the elevator is a traction elevator or hydraulic elevator; the location of the elevator mechanical room; whether the power source for the elevator is an AC or DC motor; and the type and condition of elevator motor controls. The auditor shall collect nameplate data where accessible.

19.1.2 Motor Generator (MG) Set Idle Timers

Visually evaluate idle timers for MG set elevator systems by confirming that the idle timer automatically shuts off the MG set after three to ten minutes of idling. Recommend repair or replacement of idle timer when it is not properly operating.

19.1.3 Mechanical Room Space Conditioning

Evaluate energy savings opportunities for space conditioning equipment operating in the elevator mechanical room, such as adjusting or installing thermostats.

19.1.4 Lighting and Ventilation

Evaluate energy savings and/or health and safety opportunities for lighting and ventilation systems in the elevator cab and mechanical room.

19.1.5 Air-sealing

Visually evaluate air-sealing opportunities in elevator penthouses. Prior to recommending air sealing of elevator penthouses, the auditor shall consult with elevator consultant for any potential conflicts with code requirements.

19.2 Motor and Control Upgrades

When the elevator system is nearing the end of its useful life or if an elevator replacement is planned, the auditor shall recommend a further evaluation of an upgrade to a higher efficiency system. The auditor should summarize potential upgrade opportunities and refer the property owner to an elevator specialist for further evaluation.

20 Lighting

The on-site evaluation shall include an evaluation of lighting systems and the energy audit report shall recommend upgrades as appropriate.

20.1 General Requirements

During the on-site evaluation, the auditor shall:

20.1.1 Lighting Schedule

The auditor shall create a schedule of existing lighting, including: fixture location, fixture type, lamp and ballast type, input wattage based on lamp/ballast combinations, and hours of operation as appropriate. This schedule shall be included in the energy audit report.

20.1.1.1 Ballast and Lamp Type

Fixtures should be opened to record actual ballast model numbers and lamp types installed. The auditor should verify that ballasts and lamp types are compatible.

20.1.1.2 24 Hour Fixtures

Due to their greater potential for energy savings, fixtures that are on for 24 hours should be given special consideration.

20.1.1.2.1 Foot Candle Measurement

Where spaces are suspected to be grossly underlit or overlit, the auditor should measure foot candles in the space and compare to the Illuminating Society of North America (IESNA) *Lighting Handbook* illuminance recommendations and lighting design guide for foot-candle levels.

20.1.2 Lighting Sampling

Each common area and unit space type should be sampled in accordance with Section 10 (Sampling Procedure) of this standard to confirm that lighting is consistent across each space type.

20.1.2.1 Unique Types

If lighting in a particular space is unique from other instances of that space type, additional instances of that space type shall be evaluated, to determine a representative lighting schedule.

20.1.3 Lighting Power Density

The auditor should calculate lighting power density (watts per square foot) for each space and compare to maximum lighting power density standards in ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings:*

20.1.3.1 ASHRAE Lighting Power Densities

Lighting Power Densities
Values excerpted from:
Table 9.6.1 Lighting Power Densities Using the Space-by-Space Method
ANSI/ASHRAE/IES Standard 90.1-2010: *Energy Standard for Buildings Except Low-Rise Residential Buildings,*)[6]

Common Space Types[a]	**LPD, W/ft^2**	**RCR Threshold**
Conference/Meeting/Multipurpose	1.23	6
Corridor/Transition	0.66	Width<8 ft
Dining Area	0.65	4
Electrical/Mechanical	0.95	6

[6] *ANSI/ASHRAE/IES Standard 90.1-2010), (Energy Standard for Buildings Except Low-Rise Residential Buildings*), (Section 9.6, Alternative Compliance Path: Space-by-Space Method), (Table 9.6.1)

Common Space Types[a]	LPD, W/ft^2	RCR Threshold
Food Preparation	0.99	6
Lobby	0.99	4
Lobby for Elevator	0.64	6
Lounge/Recreation	0.73	4
Office: Enclosed	1.11	8
Office: Open Plan	0.98	4
Restrooms	0.98	8
Stairway	0.69	10
Storage	0.63	6
Workshop	1.59	6

20.1.4 Fixtures with Short Lives

Where fixtures are not lasting for the expected lifetime, the auditor should obtain a basic inventory of existing replacement fixtures and try to identify any fixtures which have required a higher rate of replacement and identify possible causes and proposed solutions.

20.1.5 Lighting Controls Assessment

Existing lighting controls shall be visually inspected to verify correct operation during the on-site evaluation in accordance with the sampling procedures outlined in Section 10.

20.1.5.1 "Auto-Off" Timers

Consider "auto-off" timers (such as spring-wound interval) to replace wall switches for lights in rarely used, small space areas where lights are currently being left on (such as janitor closet).

20.1.5.2 Vacancy/Occupancy Sensors

Consider the application of vacancy or occupancy sensors in spaces controlled by individual toggle switches.

20.1.5.3 Daylight Sensors

Verify that all outdoor lighting associated with the building is controlled by daylight sensors.

20.1.5.4 Integrated Controls

Consider an integrated lighting control system that combines timing, occupancy sensing, daylight sensing, and manual controls, keeping in mind the drawbacks of too much complexity.

20.1.5.5 Controls Integrated with Fixtures

Consider suggesting fixtures with integrated occupancy sensing, daylight sensing, and manual controls.

20.1.5.6 Lighting Controls for Public Areas

Consider the application of occupancy sensors and/or bi-level fixtures to control lighting in hallways, stairwells, indoor parking, and other common areas that require 24-hour lighting. Keep in mind that additional wiring should be required to allow some fixtures to remain on so that no area will be left in the dark in the event of the failure of the control device.

20.2 Billing Comparison

The auditor should calculate annual electricity usage and demand based on operating hours input wattages collected during the on-site evaluation and compare to billed usage and demand to confirm that they are a reasonable fraction of overall usage.

20.3 Improvements or Replacements

The energy audit report shall include recommendations for appropriate replacements or upgrades to lighting fixtures and controls, including projected construction costs and energy savings.

20.3.1 Minimum Lighting Levels

Care should be taken with lighting recommendations to ensure that adequate lighting levels are provided and that applicable building codes are met.

20.3.2 Lamp Uniformity

Consideration should be given to equipment uniformity and future lamp availability for ease of future operations and maintenance.

21 Water Efficiency

The on-site evaluation shall include an evaluation of water usage at the building and the energy audit report shall recommend upgrades as appropriate.

21.1 General Requirements

During the on-site evaluation, the auditor shall:

21.1.1 Identify System(s)

Identify the water-consuming equipment in the building and document all relevant information, including: type of equipment, make and model of equipment, water flows of existing equipment, fuel type, controls, operating conditions, and any atypical end users (e.g., community kitchens). For water-consuming devices in apartment units, the auditor shall sample in accordance with Section 10 (Sampling Procedure) of this standard.

21.2 Toilets

The auditor shall quantify water usage of toilets using industry-approved water flow testing devices/processes. The auditor should evaluate water savings for replacement of existing toilets with high efficiency toilets. Replacement toilets should meet EPA WaterSense Guidelines.

21.3 Showerheads and Aerators

For information on showerheads and aerators, see Section 15.2.4 (Domestic Hot Water – Flow Measurements) of this standard.

21.4 Washing Machines

The auditor should evaluate throw valves for washing machines. Single throw valves should be considered when upgrading plumbing. The auditor should evaluate water and fuel savings for replacement of existing washing machines with ENERGY STAR® or Consortium for Energy Efficiency (CEE) Tier 1 or 2 washing machines.

21.5 Dishwashers

The auditor should evaluate water savings for replacement of existing dishwashers with ENERGY STAR® dishwashers.

21.6 Booster Pumps

Booster pumps for high-rise buildings shall be evaluated for performance and efficiency. The auditor shall evaluate alternative pumping solutions where applicable.

21.7 Irrigation System(s)

The auditor should identify the existing irrigation systems and evaluate for performance. The auditor should visually verify and record the following: system run times, positioning of sprinkler heads, visible leaks in the system, signs of overwatering, and types of irrigation distribution (overhead spray, bubbler, drip, subsurface). Irrigation system timers should be inspected and times verified either visually or data logging system to determine run times and flow amounts. Other recommendations to consider for improvements or upgrades should consider relative humidity (RH) soil meters or weather-based controllers in lieu of timers for watering. Replacing existing landscape to drought tolerant plants and/or xeriscaping are other options to consider, as well.

21.8 Gray Water or Catchment System

The auditor should identify potential for installing and/or evaluate current gray water or rain water catchment systems for performance and efficiency. Recommendations should be based on feasibility for system to be installed (including space, need, and cost) and alignment of

source of water (either rainwater or gray water) and "sink" of water- the demand for the water source.

21.9 Report

The audit report shall:

21.9.1 Calculations

Include all calculations and evaluations of existing water usage described in Section 15 (Domestic Hot Water) and 21 (Water Efficiency).

21.9.2 Recommendations

Include recommendations to improve water efficiency and reduce overall usage or potable water supply.

22 Renewable and Emerging Technologies

The on-site evaluation shall include an evaluation of existing and/or potential use of renewable energy systems. The energy audit report shall recommend upgrades as appropriate.

22.1 General Requirements

During the on-site evaluation, the auditor shall:

22.1.1 Assess Current Operation

Assess existing renewable systems for current operation.

22.1.2 Analysis Documentation

Where available, auditor shall retrieve the original analysis documentation and compare to actual operating conditions.

22.1.3 Metered Data

Where available, the auditor shall obtain metered data for system performance and compare the original analysis documentation to current operation and metered data if available.

22.1.4 System Ownership Structure

Identify the ownership structure of existing systems.

22.1.5 System Components and Schematics Diagram

Record the system characteristics and draw a diagram of the system schematics.

22.1.6 Solar Thermal Systems

Where applicable, the auditor shall collect data on the solar thermal system including the system type (open, closed loop), fluid type (glycol, water,other) storage tank size, storage tank and pipe insulation R-value, pump flow rate and size, collector panel nameplate data, valve types, and control setpoints. Actual operating conditions should be recorded including temperatures from relevant gauges. The auditor should identify

how the solar thermal system connects with the building system (boiler pre-heat for space heating, DHW pre-heat, or both).

22.1.6.1 Existing Conditions

The auditor shall identify the existing conditions of the system components including, but not limited to, soiling and shading of panels, pipe insulation quality and exposure to environmental elements, mounting systems, and storage tanks.

22.1.7 Solar Photovoltaic (PV) Systems

Where applicable, the auditor shall collect PV system nameplate data, inverter type, system configuration, generation capacity, metering structure (whole building, apartments, common area etc.).

22.1.7.1 Existing Conditions

The auditor shall identify the existing conditions of the system components, including but not limited to soiling and shading of panels, electrical connections, and mounting systems.

22.1.8 Existing Operations and Management

The auditor shall interview building maintenance staff to document the existing routine maintenance performed on equipment, including historical repairs or ongoing issues.

22.1.9 System Optimization

The auditor shall recommend repair or upgrade to any identified system deficiencies, including, but not limited to, cleaning of panels, replacement and protection of degraded insulation, replacement of storage tanks, additional operations and management tasks, and/or correction/replacement of controls.

22.2 Assessment for Potential Renewable Energy Systems

Where appropriate, the auditor shall assess the site's potential for new renewable energy systems.

22.2.1 Site Conditions

The auditor shall assess the site conditions and roofing configuration for renewable energy system potential, including identification of shading potential, rooftop obstacles, pathways for connection to mechanical rooms and/or electrical systems, and potential for interconnection with domestic hot water and/or hydronic heating systems.

22.2.2 Feasibility Assessment

Using the data identified in Section 22.2.1 (Renewables and Emerging Technologies - Site Conditions) of this standard, the auditor shall conduct a preliminary feasibility assessment for a renewable energy system. If a new renewable energy is deemed to be feasible, the auditor shall recommend further analysis be completed by a qualified professional. All assumptions shall be clearly identified in the energy audit report.

22.2.3 Professional Analysis

Further analysis completed by a qualified professional shall include a site-specific solar study and calculated offset of gas or electricity consumption due to solar generation. When conducted, this offset gas or electricity consumption shall be included in the energy audit report and cost-benefit analysis. Any offset domestic hot water and heating energy use included in the energy simulation shall be interactive with energy savings associated with installing higher efficiency heating or hot water equipment (when included in scope of work). All assumptions shall be clearly identified in the energy audit report.

22.2.4 Financing

When recommending renewable energy systems, the auditor should recommend available financing options, including purchasing agreements, leasing scenarios, and utility incentives.

22.3 Assessment for Potential Emerging Technologies

Where appropriate, the auditor should consider emerging technologies for applicable ECMs, such as combined heat and power, geothermal, advanced heat pumps. As applicable, the evaluation of such emerging technologies shall be site specific in accordance with Section 22.2 (Renewables and Emerging Technologies - Assessment for Potential Renewable Energy Systems) of this standard. The auditor shall only propose emerging technologies with documented performance and reasonable energy savings claims.

22.3.1 Projects with Existing Emerging Technology

When existing emerging technology is currently in use at the project, the auditor shall perform assessment in accordance with Section 22.1 (Renewables and Emerging Technologies - General Requirements) of this standard and manufacturer's recommendations, as applicable.

23 Fuel Switching

Where appropriate and feasible, the energy audit report shall include an evaluation of fuel switching.

23.1 General Requirements

Where the potential for fuel switching is identified, the auditor:

23.1.1 Identify Opportunities

Should identify possible cost-effective fuel switching opportunities that do not adversely affect the outdoor environment (e.g., increased pollutant emissions) in the energy audit report. When evaluating fuel switching opportunities, the estimated up-front costs, potential challenges, and necessary time frames should be summarized. Common issues that could potentially arise are permit requirements with local utilities; connection to, and availability of, utility mains; the need for addition of new meters and accounts; the building's existing electric capacity and/or gas capacity/pressure; changes to combustion

equipment including chimney types and burner types; and existing condition of oil tank and piping.

23.1.2 Identify Code Requirements

Shall identify local code requirements for fuel switching, such as phase-out of heavily fuel oils. The auditor should recommend the decommissioning and removal of phased-out equipment.

23.1.3 Use High Efficiency Systems

Shall evaluate opportunities for installing higher efficiency equipment when considering fuel switching.

23.1.4 Identify Utility Impacts

Shall analyze the potential impact(s) of any tariff rate changes to existing or new utility accounts when evaluating fuel switching.

ANNEX A|BPI-1105-S-201X Referenced Documents (Normative)

Item	Date	Relevant BPI-1105-S Section
ANSI/ACCA 5 QI-2010, HVAC Quality Installation Specification	2010	13.2
ANSI/ACCA Manual D: Residential Duct Systems		16.4.6 17.1.14
ANSI/ACCA Manual J: Residential Load Calculation	2011	16.4.6 17.1.14 17.12.2.3
ANSI/ACCA Manual S: Residential Equipment Selection		16.7.2.4 17.12.2.3
ASHRAE Procedures for Commercial Building Audits, Second Edition	2011	1.1
ASHRAE Standard 62.2 – 2013: Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings	2013	13.1.8 13.2.3
ANSI/ASHRAE Standard 111-2008, Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems	2008	13.2
ANSI/ASHRAE/IES Standard 90.1-2010 Energy Standard for Buildings Except Low-Rise Residential Buildings	2010	15.2.4 16.2.4 16.3.7 17.1.8 20.1.3 20.3.1
ANSI/ASTM E-779-10, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	2010	14.1.4.2.1
ASTM E1186-03 (2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems	2009	13.3.1
BPI Building Analyst Professional Standard	2005	12
BPI Heating Professional	2007	16.4.1 16.4.5
ANSI/BSR-BPI-1200-S-201x Home Energy Auditing Standard		All Sections
ANSI/BPI-2400-S-2012 Standard Practice for Standardized Qualification of Whole-House Energy Savings Predictions by Calibration to Energy Use History	2012	8.2
Illuminating Society of North America (IESNA) Lighting Handbook	2011	20.1.1.2.1 20.3.1
ANSI/Z223.1/NFPA 54: National Fuel Gas Code	2012	12.8
NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances	2013	12.4

RESNET Accredited Tax Credit Compliance Software Tool	2011	8.1
SMACNA HVAC Systems – Testing, Adjusting and Balancing	2002	13.2
ANSI/UL 2034 Single and Multiple Station Carbon Monoxide Alarms	2008	12.16.3.2
ANSI/UL 2075 Gas and Vapor Detectors and Sensors	2013	12.16.3.2
U.S. Department of Energy Weatherization Program Notice 11-1	2011	8.1
U.S. Department of Energy - Qualified Software for Calculating Commercial Building Tax Deductions www1.eere.energy.gov/buildings/commercial/qualified_software	2013	8.1
U.S. Environmental Protection Agency Guidelines for Radon Testing	2012	2.1.5.7

Documents can be ordered from the following:

ACCA: Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206
(703) 575-4477
www.acca.org

ANSI: American National Standards Institute
1899 L Street, NW,
11th Floor
Washington, DC, 20036
www.ansi.org

ASHRAE: American Society of Heating Refrigeration and Air-Conditioning Engineers
1791 Tullie Circle, N.E.
Atlanta, GA 30329
(404) 636-8400
www.ashrae.org

BPI: Building Performance Institute, Inc.
107 Hermes Road, Suite 110
Malta, NY 12020
(877) 274-1274
www.bpi.org

IES: Illuminating Engineering Society
120 Wall Street, Floor 17
New York, NY 10005-4001
(212) 248-5000
www.ies.org

NFPA: National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471
(617) 770-3000
www.nfpa.org

RESNET: Residential Energy Services Network, Inc.
P.O. Box 4561
Oceanside, CA 92052-4561
www.resnet.us

SMACNA: Sheet Metal and Air Conditioning Contractors' National Association
4201 Lafayette Center Drive
Chantilly, Virginia 20151
(703) 803-2980
www.smacna.org

U.S. Department of Energy
1000 Independence Ave SW
Washington, DC 20585
(202) 586-5000
www.energy.gov

UL: Underwriters Laboratories
333 Pfingsten Road
Northbrook, IL 60062
877.854.3577
www.ul.com

U.S. Environmental Protection Agency
1200 Pennsylvania Ave NW
Washington, DC 20460
(202) 272-0167
www.epa.go