San Francisco Bay Area Affordable Multifamily Retrofit Initiative[1]
AUDIT PROTOCOL:
A METHODOLOGY FOR CONDUCTING
AN INVESTMENT GRADE ENERGY AND WATER CONSERVATION AUDIT
OF MULTIFAMILY PROPERTIES
Amended October 25, 2010

I. Overview

The **San Francisco Bay Area Affordable Multifamily Retrofit Initiative** Audit Protocol (the "Protocol") is a tool that defines the required criteria for an audit to be used by loan underwriters to determine if energy and water conservation measures can be put in place to save enough money to pay for debt service that finances all, or some portion of, the improvements. It is imperative that the audit be of investment grade caliber, which means that its data and analysis is deemed reliable to take on the risk of lending money to the project. Since there is no current industry established protocol for what determines an investment grade audit for retrofitting multifamily buildings, the **San Francisco Bay Area Affordable Multifamily Retrofit Initiative** is establishing its own protocol that it will share with the affordable housing industry for implementation and ongoing refinement. Underlying this protocol are the principles of transparency, consistency, and accountability: data contained in the audit must be totally transparent in terms of methodology of collection and calculation; reports must be presented in a consistent manner, in terms of format and content; and persons completing the audit must be accountable for their work by adhering to protocol requirements, maintaining professional certifications, and providing quality assurance measures.

A key objective of the audit is to identify ways to save the maximum amount of energy and water at a property as cost efficiently as possible, with the goal of attaining a 25% overall reduction. In addition to trying to identify ways to save energy and water, the audit process must also conduct an evaluation of the integrity of the building to identify any deficiencies that could result in health and safety hazards to tenants, code violations, and/or degradation of building systems that jeopardize the long term viability of the building over a minimum ten year horizon.

Finally, the audit process will also identify green measures that may not have financial payback, but that improve comfort and indoor air quality and that create a safer and quieter home environment for the tenants and property management workers, and reduce the property's negative impact on the environment.

The outcome of the audit process is an assessment that clearly reports on:

- Current energy and water use
- Energy efficiency and water conservation measures that could be installed

[1] The Initiative is a partnership of the City of San Francisco Mayor's Office of Housing, Enterprise Community Partners and the Low Income Investment Fund.

- The physical condition of the property and recommended capital improvements that relate to the health, safety and viability of the property over at least a ten year period.
- Well integrated green measures that deliver not only energy efficiency and climate change mitigation, but also improved comfort, indoor air quality and create safer and quieter home environments
- A simple payback and life cycle cost analysis of each recommended energy efficiency and water conservation measure
- The total reduction in energy or water usage for the recommended measures
- The energy modeling software and assumptions used to make the projections
- The methodology of data collection and relevant calculations, as reasonably feasible
- A Quality Assurance and Verification Plan to be carried out upon completion of retrofit installations and possibly a 12 month monitoring inspection as well
- The qualifications and certifications of all persons who worked on the audit
- A representation that the Audit meets the San Francisco Bay Area Affordable Multifamily Retrofit Initiative Audit Protocol as defined here.

The San Francisco Bay Area Affordable Multifamily Retrofit Initiative Audit Protocol standards are derived from the following standards:

- Building Performance Institute, Inc. Technical Standards for Multifamily Building Analysts (2008)
- HERS II 2008 Technical Manual
- Title 24-2008 Standards for Residential and Non-residential Buildings
- HUD, Energy Conservation for Housing: A Workbook (1998)
- RESNET, RESNET Standards Chapter Seven, Comprehensive Home Energy Audit
- ASHRAE, Commercial Building Audit Standards (2004)

The three main processes that constitute the San Francisco Bay Area Affordable Multifamily Retrofit Initiative Audit Protocol standards include the on-site visit, the energy modeling and energy/water savings analysis, and reporting.

II. Auditor Qualifications

The San Francisco Bay Area Affordable Multifamily Retrofit Initiative Audit Protocol requires that auditors perform, at a minimum, the following seven tasks:

1) Energy modeling
2) Building assessment (limited to identifying safety, code and durability issues)
3) Diagnostic testing (see Attachment C)
4) Combustion appliance safety testing
5) Feasibility analysis for the installation of renewable energy retrofits
6) Construction cost estimating
7) Financial analysis that generates investment grade level information/data

In recognition that a single firm may not be able to fulfill all the requirements of this audit protocol, multi-disciplinary teams assembled for their complementary skill sets are welcome to apply. Potential team members may include, but are not limited to:

- HERS Rater
- BPI multifamily analyst
- General Contractor
- Architect
- Mechanical Engineer
- Electrical Engineer
- Certified Energy Manager (CEM)
- Energy modeler
- Title 24 Compliance consultant
- Certified Green Building Professional
- Retrocommissioning agent
- Renewable energy expert

At least one member of the team must either be HERS II or BPI multifamily analyst certified. Applicants who do not hold these certifications but can evidence equivalent training and experience will be considered on a case-by-case basis.

III. On-site Process (BPI 3.5[2]).

There will be two on-site meetings held. The first will be a "pre-audit meeting" with the following parties:

- Auditor and its team members
- Owner (to include property operations and maintenance staff)
- Lender (LIIF or Enterprise)
- City staff (optional)

The purpose of the pre-audit meeting will be to establish and confirm the understanding of the following variables, but may include discussion of additional items:

- Diagnostic testing to be conducted
- Energy modeling software to be used, and should it entail more than one, then the outcome that will be reported in the final audit document
- Wage rates to be factored into cost estimates
- Confirmation of Savings to Investment ratio formula
- If Weatherization Assistance Program funds may be involved in the project, discuss requirements attendant to that program that will impact the audit inspection, testing and written report
- Review of Site Visit Preparation Checklist, Attachment "A"

[2] The energy code or technical standard that has information related to the section is listed in parenthesis. For example, (BPI 3.5) refers to section 3.5 of BPI Multi Family Building Analyst Professional technical standards. HR=HERSII. T24=Title 24-2008. ASH=ASHRAE Commercial Building Audit Standards.

It is recommended that the pre-audit meeting occur prior to finalizing the contract for audit services with the owner.

The second meeting will be the "on-site visit" and will take place on the day of the site inspection. The purpose of the on-site visit is to collect all necessary information to conduct an appropriate energy, water, health and environmental analysis, including sufficient information to inform an energy model. The intent is to interview property owners and managers, evaluate the building envelope, assess building airflow, inventory HVAC equipment, identify ventilation system, field verify fan operation, and perform other diagnostic testing.

1. Auditor Conduct Standards
    - The Auditor shall comply with applicable professional standards for ethics as defined by the HERS Code of Ethics and/or Building Performance Institute Code of Ethics[3].

2. Scheduling the Site Visit and Tenant Notification
    - Notification of tenants whose units will be inspected as part of the audit site visit will be the sole responsibility of property owner or their representative.
    - The Auditor shall schedule the site visit(s) with the designated person(s) at a time that is convenient for the project contact person(s). The site visit should seek to cause minimal disruption to the tenants and neighbors at the project.
3. Site Visit Preparation
    - The auditor shall complete the site preparation tasks as described in Attachment A
    - Review the Initial Building Assessment or similar screening report which establishes the building's eligibility to participate in the Initiative
    - Review 12 months of prior utility bills (including gas, electric and water) to know annual utility cost by fuel type and seasonal variations. (BPI 1.7)
    - Review as-built drawings (if available) and any other pertinent information about the site, the building and its systems, to be provided by Owner. (BPI 1.8)

4. Site Visit

The on-site energy and water audit shall be comprised of an in-person visit to the project by a qualified Auditor to complete the following tasks:

4.1 Project Interview(s) (BPI 1.9 through BPI 1.13)

The Auditor shall interview at least one of the following designated person(s) prior to or at the time of the site visit:

- Property Manager
- Maintenance Director or maintenance staff
- Owner or owner representative

[3] Building Performance Institute, Code of Ethics, as referenced in section 1.1, BPI Standards for Multifamily Analysts (2008). Resnet (HERS raters) Code of Ethics as referenced at http://www.resnet.us/standards/ethics

The purpose of the interview(s) is to:

- Discuss project energy and water performance
- Discuss tenant comfort, health and safety and agree on a tenant synopsis for the site visit
- Discuss operations and maintenance procedures
- Address any other stakeholder questions or concerns

The interview shall include questioning on operations and maintenance issues and will address the issues including but not limited to those in Attachment B. If any project team member wishes their responses to remain confidential, the Auditor shall respect those requests.

4.2 Safety and Code Observations at the Site Visit (BPI 3.4)

If, during the course of the site visit, the Auditor observes the existence of an issue that, in his or her judgment, may be a building code violation or a potential threat to health or safety, the Auditor shall immediately notify the designated person(s) in the project application and/or any individuals that are present representing the owner.

4.3 Visual Inspection and Diagnostic Testing Protocols

The site visit shall involve visual inspections and diagnostic testing of the building envelope, HVAC, combustion safety, and lighting systems. All items listed in Attachments C and D, ***as applicable***, will be performed during the site visits.

Attachment C identifies the categories for testing systems, a description of what is to be accomplished with each test, suggested testing protocols, equipment and certifications required for testing. Attachment D identifies the building categories to be inspected: building envelope, HVAC and domestic hot water, a description of what is to be inspected and inspection protocols.

At a minimum, the Auditor shall identify and record equipment specifications listed on the form attached as Attachment E. The equipment specifications will be used in the energy modeling and analysis phase of the audit.

If the operating parameters of HVAC equipment or lighting system are not known to a high degree of confidence, and this information is necessary for accurate energy cost savings analysis, the auditor may suggest short term monitoring of the systems to measure the actual operating conditions. The intent is to better inform the energy cost savings analysis. The Auditor must decide what is to be observed and measured and with what confidence and precision.

4.4 Dwelling Unit Sampling Protocols

At least one in seven of every dwelling unit type (defined as having same/similar floor plan), with representation from differing building floors and including all four building orientations shall be inspected. In no case shall the inspection of units be less than 10% of total units. A larger sampling may be necessary depending upon funding source needs

and other special circumstances. In accordance with Attachment A, Auditor will ensure that a discussion of unit sampling addresses special building circumstances that may result in an increased level of unit inspections and testing.

4.5 Renewable Energy

The on-site inspection will also examine, evaluate and propose recommendations for the incorporation of renewable energy opportunities, including but not limited to, solar hot water and solar photovoltaics. The solar thermal analysis to estimate the amount of DHW that can be potentially be offset with a solar thermal system should be determined with the California Solar Initiative OG-100 solar calculator which is a free on-line tool used to calculate potential therm savings and incentives for the selected built-up solar system. The proprietary F-chart software or RetScreen may also be used to calculate the potential therm savings. PV Watts is to be used to estimate the potential electricity offset by utilization of photovoltaic panels.[4] Utilization of other calculation tools or approaches based on accepted engineering principles are acceptable and must be pre-approved prior to use.

IV. Energy Modeling and Analysis Process (BPI 2.11 – BPI 2.17)

An energy model of the building's pre- and post-retrofit performance shall be completed using building plans, initial inspection data, and diagnostic data collected during the on-site visits. The energy model is used to estimate annual energy consumption and energy cost savings of potential energy conservation measures. Current operating schedules verified on-site are to be used for energy and energy cost savings estimates. Operating schedules embedded in Title 24 software are used for compliance analysis.

All major assumptions used to develop the energy model and analysis must be clearly stated in the final report. Reporting emphasis should be placed on the assumptions that have the most impact on estimated energy savings. Occasionally, some building features may be inaccessible, such as crawl space insulation values. When certain building features can not be physically verified, values from Table R3-50, Default Assumptions for Existing Buildings in the 2008 Title 24 Alternative Calculation Method manual, shall be used as default conditions in the energy model and analysis.

Additional modeling requirements include:

1. *Energy Modeling Software Requirements*:
    - Auditor shall use either TREAT or EnergyPro as currently approved for low-rise and high-rise.
    - Certain projects receiving funding from the California Department of Community Services and Development weatherization program may be required to use RemRate or RemDesign software.

[4] https://www.csithermal.com/calculator/commercial/
http://www.nrel.gov/rredc/pvwatts/version2.html

- As noted in Section III., the "pre-audit meeting" will be used to confirm the energy modeling software to be used for the subject audit report.
- The modeling software shall use hourly heating and cooling load calculations based on ASHRAE fundamentals (BPI 3.5)
- To maintain connection with weatherization program and other subsidy programs, the Auditor must use energy modeling software or other utility analysis that complies with the project's local weatherization or other subsidy program requirements.
- Permission required prior to utilizing other energy modeling software.

2. *Ordering of Energy Efficiency Measures:* the loading order of energy efficiency measures in the energy modeling analysis shall be structured so that improvements to the building envelope and interior lighting are modeled prior to improvements to the HVAC system. The intent of this loading order requirement is to capture all of the potential effects of envelope and lighting energy efficiency measures on cooling and heating loads and subsequent investigation into impact of energy efficiency measures pertaining to HVAC equipment.

3. *Energy Efficiency Measure Alternatives:* The analysis and report should include less costly alternatives in case there is not enough funding to pay for the optimal measure. Potential alternatives may include weatherization measures in lieu of window and door replacement. Retro-commissioning of boiler systems instead of replacing the boiler is another low-cost alternative if the equipment still has a reasonable expected useful life (EUL). The energy savings for all measures analyzed should still be presented in the report to show their impact, and those not suggested for implementation are to be excluded from the combined alternative package of suggested measures.

4. *Utility Rates:* the energy consultant shall model the building using the current local utility rate schedules as verified during review of utility bills. The local utility rate may have to be created in the energy modeling software. Energy cost savings calculated outside of the modeling software shall be based on actual utility rates used by the building. An average or "blended" utility rate, accounting for monthly service and time-of-use charges, shall not be used to calculate energy cost savings.

5. *Model Calibration:* the energy model for buildings that are mastered metered shall be calibrated to actual utility billing data. Modeled baseline energy consumption shall be calibrated to monthly utility bills for a minimum of twelve months. The intent is to establish the modeling results verified for consistency and accuracy.
    - The energy model estimates of electricity and natural gas should calibrate to actual monthly consumption to within 10%.
    - TMY 30 year average weather data can be used in lieu of actual year weather, which may be difficult to obtain.

- Any adjustments made to the building description inputs used to calibrate the simulated building to actual energy usage must be justified with explicit, transparent information and documented in this section of the audit report.
- If Title 24 default building schedules were modified in order to calibrate energy model to utility data, the modified schedules shall also be used to estimate annual energy cost savings.

6. *Exceptional Calculations*: Energy conservation measures not directly modeled with the energy modeling software can be calculated outside of the program provided that generally accepted engineering calculations and methodologies are used. Interactive effects must be accounted for in exceptional calculations. The methodologies, assumptions, and constants used in the exceptional calculations must be clearly documented in the final report. Sources of deemed savings must be referenced.

7. Sampling for Energy Analysis: If the project is comprised of multiple buildings, the whole building-simulation shall include at least one example of each building type. If units are individually metered and billed, the Auditor should sample at least one kind of each unit, consistent with BPI Technical Standard 2.2 (Utility Usage Analysis) and BPI Technical Standard 3.1 (Sampling Procedures).

V. Written Report[5]

Auditor shall prepare a written report which will have the following features:

Section 1: Executive Summary

The Executive Summary shall summarize the major findings of the audit, including:

- Basic building characteristics such as unit count, building construction type, number of stories, year built, total building area identified by use (residential, community/common, commercial), history of previous retrofits or rehabs, and other significant building features,
- Overall physical condition of the building (good, fair, or poor with respect to structural integrity, maintenance and repair)
- Recommended energy efficiency and water conservation measures
- Recommended green measures and other capital improvements needed to ensure long term integrity of building
- Estimate of cost to install each recommended measure. Must use a combination of RS Means, plus local adjuster, plus Davis Bacon wage rates and available current data from Auditor or Owner based on prior experience and/or internal bid database.
- An excel spreadsheet of all recommended measures and their cost, to accompany the report,
- Projected savings from implementing each energy efficiency and water conservation measure both in dollars and KWh and Therm

[5] If it is determined prior to issuance of the final report that a recommendation conflicts with local, state and national codes and regulations, the recommendation shall be revised or removed from the report.

- Comparison of total projected savings to existing energy use/cost,
- Savings to Investment Ratio of each measure. As of this writing, the SIR is to be calculated by dividing the savings per year by the payment amount (taking into account the discount rate and estimated useful life of the equipment) divided by the cost of the measure. Using Microsoft Excel this equation is expressed as[6]:

$$SIR = Savings\ per\ year\ (\$) \div PMT(3\%\ discount\ rate, Estimated\ Useful\ Life, -1) \div Measure\ Cost\ (\$)$$

**Estimated Useful Life for recommended measures is to be derived using the EUL values used in the Database for Energy Efficiency Resources (DEER) database used by CA utilities for energy efficiency retrofits[7] and for weatherization purposes shall not be greater than 20 years for a given measure.*

As noted in Section III., the "pre-audit meeting" will be used to confirm the SIR calculation to be used for the subject audit report.

- Projected carbon footprint reduction
- Date of the site visit
- Names of the individuals interviewed

Section 2: Narrative

This section shall include a written narrative that describes existing property conditions in the following categories:

- Site
- Building Envelope including roof and windows
  - Air flow
  - Insulation
  - Ducts
- Building Mechanical and Electrical Systems, including (when applicable):
  - Heating systems
  - Ventilation systems
  - Cooling systems
  - Electrical systems
  - Elevators
- Mechanical Room, including (when applicable):
  - Boilers

[6] EnergyPro doesn't calculate the SIR; therefore it must be calculated in Excel using the PMT function. The Microsoft Excel help file explains the PMT function calculation.

[7] http://www.deeresources.com/deer2008exante/downloads/EUL_Summary_10-1-08.xls

        - Domestic Hot Water
        - Plumbing Systems
    - Common areas including community rooms/kitchens, lobbies, corridors, and commercial spaces
    - Dwelling Units, as relates to: health and safety, energy efficiency and water conservation

The Auditor shall include in the narrative information from the site visit to verify the building drawings. If the site conditions do not match design conditions, the site conditions shall be used for analysis and reporting (BPI Standard 3.3 Blueprint Evaluation/Site Visit). This section will include information on equipment specifications in accordance with Attachment E.

Section 3: Photo Documentation
This section of the report should include photo documentation of the subject property, specifically targeted toward describing the relevant physical conditions and energy efficiency and water conservation measures.

Section 4: Description of Energy Efficiency, Water Conservation, Green and Capital Improvement Recommendations
This section will provide information on each recommended measure and improvement, including, but not limited to:

- Description of measures and recommended loading order
- Rationale for recommendation
- Estimated useful life of existing component
- Recommendation for timing of implementing the measure/replacement/improvement
- Identification of how cost estimate was derived (including source of cost information, unit pricing, take-off used)
- In the absence of renewable energy opportunities, explain why these are not recommended
- Non-energy related benefits of the recommended measures such as health and safety, improved indoor air quality, and increased resident comfort

Auditors will present this information as an Optimal Green Improvement Plan that includes the most cost-effective combination of recommended measures and improvements factoring in loading order, available funding, estimated useful life of existing equipment/systems and property owner goals.

This section will include the results of the diagnostic testing conducted on-site and describe how the test results informed the rationale for the above recommendations. Auditors may also offer recommendations for the retrocommissioning of certain existing equipment based on diagnostic test results.

This section of the report will also include a summary of the combustion analysis testing completed during the energy audit. For all audited dwelling units, include the results of combustion safety testing and identify if action was warranted as a result of the combustion safety testing. Report recommendations to include CO detectors to the extent the dwelling units don't have them installed.

Section 5: Energy and Water Audit and Analysis

a. Energy and Water Analysis Methodology

This section of the report should summarize the energy modeling approach and other calculation methods used in the energy and water analysis. Include name and version of energy modeling software used and indicate if exceptional calculations are used to estimate energy and energy cost savings. Provide a summary of the approach, and detailed calculations, used in any exceptional calculations used for analysis.

b. Utility Analysis and End use Breakdown

This section shall describe the applicable end use(s) for each type of fuel at the project and present a visual breakdown of annual energy and energy cost by fuel type.

- The Auditor shall graph energy usage for each fuel type for a minimum of 12 months (BPI 2.8).
- The Auditor shall review the utility rate structure to determine if it seems appropriate for the project (BPI 2.10; 5.6).
- The Auditor shall make a recommendation for further investigation if the Auditor finds that the rate structure does not match the utility data (BPI 2.10).

c. Source of Information

This section briefly describes all sources of information used to inform the analysis including:

- The source and scope of utility billing data supplied to the Auditor including the data source, the data duration in months over which the data covers, and whether the Auditor received copies of the actual utility bills or electronic interval data.
- Construction cost information used in economic analysis
- Report if building plans or site verified data was used in the analysis
- Report any discrepancies between plans and verified conditions.
- Utility rate and schedules
- Source of deemed energy savings

d. Energy Model Inputs and Assumptions

The audit shall clearly state any assumptions used when analyzing energy and water utility data. (BPI 2.14). This section of the report shall include an "Input Assumptions Table" which reports an overview of all model inputs for both the standard case and proposed case energy models. This table should also highlight building components that were analyzed as potential energy conservation measures and those having greatest

impact on final energy cost savings estimates. The "Input Assumptions Table" will be in the form of Attachment "F."

e. Energy Model Documentation

Provide final energy model input and output files used to report energy and energy cost. A log of all final justified adjustments made to the energy model during the calibration process must also be submitted in the final report.

Section 6: Energy Efficiency and Water Conservation Cost/Benefit Analyses

This section shall include the individual cost/benefit worksheets for each recommended energy efficiency and water conservation measure. The worksheets should show implementation cost, energy and water consumption and financial savings, simple payback, and incremental payback (as applicable).

Section 7: Quality Assurance and Verification Plan

This section shall include a written plan that outlines the recommended process for the visual inspection of all newly installed components, and verification of their performance both at the completion of construction and twelve months thereafter. This Plan shall be in accordance with the "Post Measure Installation Verification, Inspection and Test Out Requirements for Project Quality Assurance," attached as Attachment "G."

Section 8: Qualifications and Certifications

This section shall include a description of the qualifications and professional certification of any person who worked to produce it.

Section 9: Representation

This section shall include a representation from an officer or owner of the firm conducting the audit that the audit meets the San Francisco Bay Area Affordable Multifamily Retrofit Initiative Audit Protocol without exception and that the final audit report has been reviewed for quality assurance purposes by a principal or officer of the firm.

ATTACHMENT "A"
Site Visit Preparation

LOGISTICS
Cell number and email address for site contact person
Parking instructions/options
Intercom codes for entrance to facility
SELECTION OF SAMPLE UNITS
Select sampling of units representative of unit types, conditions, sizes, locations
Work with Green Retrofit Program to identify which commercial spaces will be inspected
Arrange access with residents
RESIDENT NOTIFICATION/INVOLVEMENT
Formal notification of residents re: inspection
Formal notification of commercial space tenants
Select best approach to obtain resident input; individual interviews, resident representative/s or small group
DEVELOPER STAFF INVOLVEMENT
Reps from property management, O&M and services to attend kick-off mtg.
Staff person to accompany inspection team on visits to residents' units
Translator if needed to conduct interviews with residents
O&M staff person who is most knowledgeable about the building and its facilities history available for interview
INFORMATION NEEDED AT SITE VISIT
As-builts; one copy to review at the site (do not require a separate copy). Also any specifications manuals
Physical Needs Assessments conducted within the past 10 years
Description and Costs (actual or estimates) of each retrofit, remodel, or improvements within the past 5 years
Renewable energy feasibility assessments ie solar PV, HW
All meter locations and areas they cover
Operations & maintenance records/logs/protocols
HVAC equipment and control systems info
HVAC equipment repair records/log
Pest management protocols and product info (MSDS sheets)
ACCESS REQUIRED DURING SITE VISIT
All mechanical rooms and all HVAC, domestic hot water, cogeneration equipment
Elevator room/s
Roof/s
Sampling of residential units (see above)
Recycling/waste disposal areas
Electrical panel/s
Basement
Attic
Commercial spaces

ATTACHMENT "B"
Potential O&M Problem List

Potential O&M Problem	Affected Equipment	Description
Malfunctioning equipment: air conditioners, exhaust fans, ventilation system, pumps, chillers, boilers, etc **Overheating motors, excessive motor cycling, etc**		
Malfunctioning dampers or actuators		
Malfunctioning or commonly over-ridden thermostat programs **Trouble maintaining hot water supply temperatures**		
Leaky or faulty valves, pumps, pipe connections, etc		
Leaky hydronic coils		
Terminal units: noisy operation, inadequate air flow, or too much air flow **Malfunctioning or commonly over-ridden thermostat programs** **Improper EMS controls programming, or not working as intended** **Inaccurate or faulty sensors, zone level thermostats, Improper sensor location** **Trouble maintaining supply air temperatures**		
Excessive comfort complaints		
Malfunctioning lighting controls: occupancy sensors, sweeps, etc		

ATTACHMENT "C"
Diagnostic Testing List

Diagnostic Test	Diagnostic Testing Description *(numbers in parenthesis refer to reference documents related to the test)*	Suggested Testing & T24 Required Testing	Required Equipment
Blower Door (Building Envelope Tightness)	Perform a blower door test to measure air leakage between sampled units or floor/building to the exterior. Close all windows and doors and use blower door equipment to pressurize the test area to 50 Pascal's (CFM50). Once the test area is pressurized, using a smoke pencil and visual observations, the tester shall inspect all potential areas of infiltration to identify leaks in building envelope relative to the outside and adjacent units. **(6)** Depending on whether or not the dwelling units are compartmentalized, and pending participation in other incentive programs that require blower door testing, blower door testing may be required using one of the following approaches: 1) an entire floor to measure leakage to exterior for that floor or 2) measure the leakage to outside and unit to unit leakage by sampling several dwelling units. Seal off all adjacent units and test leakage to exterior and unit to unit for sampled space.	Blower door testing of individual units is required for projects participating in CA Community Service Department (CSD) weatherization program and projects must follow the CSD blower door testing protocols. Blower door testing may be required for smaller sized low-rise buildings when testing an entire floor is feasible, or to test-out air sealing measure effectiveness. Confirmation of blower door testing will be determined at the pre-audit meeting.	Blower door
Smoke pencil and Infrared Camera (Building Envelope Sealing)	Use smoke pencil and infrared cameras in conjunction with blower door testing, or as an alternative, as an accurate approach to assessing building envelope sealing. This is an easy way to identify places with inadequate insulation and building sealing, identify areas of high heat transfer, and can also identify water intrusion for the prevention of mold and water damage. **(1)**	Building envelope tightness testing using a smoke pencil and/or infrared camera is required for all audited dwelling audits and conditioned common areas for all projects. Using a smoke pencil and infrared camera to test envelope tightness is not specifically required by T24.	Smoke pencil, Infrared camera

Diagnostic Test	Diagnostic Testing Description *(numbers in parenthesis refer to reference documents related to the test)*	Suggested Testing & T24 Required Testing	Required Equipment
Quality Insulation Installation	Inspect attic insulation for incomplete coverage and compression and determine insulation effective R-value. Inspect attic for thermal bypass, moisture migration, air movement through insulation. **(6)**	Insulation installation quality is a required diagnostic inspection and is to be completed on all projects. Optional T24 credit for major remodel in low-rise projects in some CA climate zones.	Infrared camera
Central DHW / Hydronic Heating Systems	Components of the central DHW systems to be inspected for safety issues, and energy/water conservation include: i. Aqua stat setting for tank temperature ii. Settings for delivered hot water (re-circulation Aqua stat or anti-scalding mixing valve) iii. Venting path and detection of vent gas spillage iv. Gas (natural gas or propane) leakage v. Water leakage vi. Electrical connections and controls vii. Secure access to the controls, valves, and burners is secure viii. Combustibles on or around the gas appliance ix. Proper operation of the pressure/temperature relief valve x. Presence of and quality of pipe insulation	All central DHW and central hydronic heating systems are required to be inspected and diagnosed. It may be necessary for a person specially trained in large hydronic systems to inspect complex systems serving large high-rise residential buildings. Testing is not required by T24.	

Diagnostic Test	Diagnostic Testing Description *(numbers in parenthesis refer to reference documents related to the test)*	Suggested Testing & T24 Required Testing	Required Equipment
	xi. Water outlet temperature at sampling of delivery points and compare to set point xii. Actual gpm of fixtures by sampling of delivery points xii. Supply temperature reset control strategy is operating as-designed, and if outdoor air reset control, confirm outdoor thermometer reading correctly. xiii. On DHW systems serving multiple dwelling units, inspect for presence of recirculation pump controls and assess retrofit potential for demand and temperature modulation controls.		
Centralized Ventilation Systems	Check to see if the ventilation system is working at all does the job as effectively as possible. i. Measure the fan volume and verify flow direction ii. Measure fan power. iii. Verify the actual and intended schedule of operation. iv. Compare actual flow rates with minimum required flow rates according to ASHRAE 62.1 Standard v. Inspect all dampers for obstructions vi. Inspect bearings, pulleys, motor housing, for wear and tear **(3)**	Testing of all central ventilation systems is required. Ventilation system testing is not required by T24.	anemometer, duct blaster, flow hood, smoke pencil, power meter
Exhaust Fan Testing	Test operation of kitchen, bathroom shower exhaust fans to ensure they are operating using the following procedures: i. Measure flow rates of bathroom exhaust fans and kitchen hood fans. ii. Use smoke pencil to verify correct airflow direction.	Testing of all exhaust fans in sampled dwelling units is required. Exhaust fan testing is not required by T24.	Anemometer, duct blaster, flow hood, smoke pencil, power meter

Diagnostic Test	Diagnostic Testing Description *(numbers in parenthesis refer to reference documents related to the test)*	Suggested Testing & T24 Required Testing	Required Equipment
Combustion Analysis and CO Testing	In all audited dwelling units, perform the following three combustion diagnostic tests on furnaces, space heaters, water heaters, or boilers, as applicable. CO testing of stoves is required; backdraft or spillage testing of stoves is not required. 1. Standard and worst case draft/spillage testing. 2. Combustion efficiency analysis 3. Ambient carbon monoxide (CO) and flue-gas testing. As applicable, for audited dwelling units, every combustion appliance will also be checked for a safe flue pipe, chimney or vent, adequate combustion air and gas leaks. **(4,5)**	Perform combustion analysis and CO testing in all audited dwelling units, as applicable to equipment located in the dwelling unit. A post-installation safety inspection of all combustion appliances must be completed whenever changes to the building envelope and/or heating system are part of the work scope. Analysis and testing is not required by T24. For projects participating in CA Community Service Department (CSD) weatherization program, testing must also utilize Combustion Appliance/Duct Leakage Testing protocol of the Weatherization Installation Manual prepared by the CA CSD.	Digital combustion analyzer ((w/CO and O2), CO meter
Duct Leakage	Duct leakage tests measure the air leakage relative to total system airflow. The ducts can be tested for leakage to outside, or total leakage to outside and the house. At the system air-handler, the duct system is pressurized to 25 Pascal's relative to the outside using a fan flow meter, and the loss is measured using a static pressure probe inserted into the duct system. When used in conjunction with theatrical fog (smoke test) the location of the leaks can also be identified. New or replacement systems: less than 6% of system fan airflow (24 cfm/ton). Component replacements: Less than 15% of system fan airflow (60cfm per ton) or more than 60% reduction in leakage. **(1,5,6)**	Duct leakage testing is required in all sampled dwelling units that have ducted heating and/or cooling systems. The exception is for ducted systems with ducts located within the conditioned space; testing is not required for these systems. T24 requires duct testing when any of the following are replaced: -Air handler or furnace -Furnace heat exchanger -Outdoor condensing unit -Package unit -Heat Pump -40 linear feet or more duct work in conditioned space	Fan flow meter, duct blaster, static pressure probes

Diagnostic Test	Diagnostic Testing Description *(numbers in parenthesis refer to reference documents related to the test)*	Suggested Testing & T24 Required Testing	Required Equipment
Cooling Coil Airflow	Measure airflow across the cooling coil of air conditioners and heat pumps to verify that the airflow is as-designed and providing sufficient ventilation to the space. Inadequate airflow can reduce the cooling capacity of the system, and can result in ice build-up on the cooling coil. Target rate: 350 cfm/ton of nominal cooling in every zonal control mode. 300 cfm/ton necessary for refrigerant charge test. As an alternate to measuring the flow with a fan flow meter, the temperature split approach can be used. **(1,2,6)**	This test can be performed at the same time as the duct leakage testing since the total airflow is measured during the duct leakage diagnostics. This test should be conducted on existing units, and with the replacement or installation of space-conditioning components.	Fan flow meter and flow grid or flow hood, duct static pressure measurement probes
Air Handler Fan Watt Draw	Excessive fan watt draw can indicate high duct pressure drops caused by impediments in the ducts. This test determines the fan W/cfm of delivered air. Target of 0.58 or fewer watts per CFM of measured airflow. **(1,2,6)**	This test can be performed at the same time as the duct leakage testing since the total airflow is measured for each test. The air handler fan watt draw test should be conducted on existing units. Required by T24 when a new or replacement space-conditioning system is installed.	Power meter, fan flow meter, duct pressure measurement device
Refrigerant Charge	HVAC tune-up measure for split system air conditioners and heat pumps to ensure the system has the appropriate refrigerant charge. Improperly charged systems (either too much or too little refrigerant) can lead to inefficient operation and potential compressor failure. Utilizing a refrigerant pressure gauge system, run the A/C for at least fifteen minutes to ensure steady state operation, and measure the pressures of the discharge and suction lines of the system. The temperatures of these lines, in addition to other system dry-bulb and wet bulb temperatures, also need to be measured to assess actual refrigerant charge. **(1,6)**	This test should be conducted on existing units, and with the replacement or installation of space-conditioning components. The test can be performed on both packaged and split system air conditioners, and are typical used on systems ten tons and less which are the expected sizes for residential systems. Required by T24 when a cooling coil or condenser unit is replaced.	Refrigerant manifold testing system

ATTACHMENT "D"
Inspection List

Building Component	Inspection Protocol Description	Related Standards			
		Title 24 - 2008			BPI
		Res ACM	NR ACM	Ref App	
Building Zone Information	Determine # of levels, quantity of living units, location of common areas and/or commercial space	3.3.1			
	Measure floor areas				
	Calculate conditioned volume of space				
	Identify crawlspaces				
	Determine if basement is unconditioned, directly conditioned, or indirectly conditioned				
Thermal Mass	Determine if inside surface of slab on grade is covered or uncovered.	3.3.2			
Natural Ventilation and Infiltration	Determine if natural ventilation is only source for cooling. Observe general building condition for impact on infiltration rates, i.e. thermal bypass in insulation, spaces under doors and next to windows, duct system.	3.3.3			
Roof Pitch and Attic Geometry	Determine roof pitch	3.4.1			
	measure the area of all ceiling surfaces and identify the ceiling as next to: attic, exposed beams or rafters, or finished framed ceiling				
Ceiling / Framing Assembly Construction (Attics)	Determine R-value of ceiling insulation	3.4.2			
	Determine type and spacing of framing				
	Determine construction assembly from 2008 Title 24 Reference Appendix JA4				
	Determine insulation quality 2008 Title 24 Reference Appendix RA3 section 3.5				
	Check for radiant barrier				
Attic Ventilation	Determine free ventilation area	3.4.3			
	Determine the % of ventilation area located high				
Flat Roof Construction (roof deck above attic)	Determine solar reflectance/emissivity	3.4.4			
	Determine roofing surface				
	Determine above deck roof insulation				
	Determine roof mass				
	Determine depth of framing				
	Check for radiant barrier				
	Determine below deck insulation				
	Check insulation installation quality				
	Check ceiling framing				
Non-attic Ceiling and Roof Construction	Determine surface area	3.5.1			
	Determine orientation and tilt				
	Detemine the assembly u-factor				
Exterior Walls	Determine whether walls border exterior space, attic, garage or crawl space	3.5.2			

	Determine wall orientation	
	Determine surface area of all walls exposed to unconditioned space	
	Determine construction type	
	Determine framing size for all framed walls exposed to unconditioned space	
	Check insulation installation quality	
	Determine type and thickness of all mass walls	
Basement Walls and Floors	Determine area of basement walls	3.5.3
	Determine insulation in walls and floor of conditioned basement or crawl space	
Raised Floors	Measure floor area over crawlspace	3.5.4
	Measure floor area over exterior space	
	Measure floor area over unconditioned garage	
	Determine floor insulation level and u-factor	
	Check insulation installation quality	
Slab-on-grade	Identify slab on grade foundation	3.6
	Determine perimeter of slab foundation	
	Determine perimeter and interior areas that are exposed	
	Determine if slab perimeter insulation exists and determine insulation depth and R-value	
Doors	Determine construction type of doors	3.7.1
	Determine orientation of doors	
	Determine surface area of doors	
	Determine whether doors are insulated	
	Determine door U-factor	
Fenestration Types and Areas	Determine area of windows by orientation	3.7.2
	Determine window framing type	
	Determine window glazing characteristics	
	Determine solar heat gain coefficient of glazing	
	Determine window U-factor	
	Determine area of skylights	
	Determine framing and glazing characteristics of skylights	
	Determine orientation and tilt of skylights	
	Determine U-factor and solar heat gain coefficient of skylights	
Overhangs and sidefins	Determine overhang dimensions	
	Determine side fin dimensions	
Infiltration and Buidling Airflow Assessment	Inspect for possible locations of thermal bridging	3.11
Multiple Ssytem Types	Determine floor area served by each system.	
No Cooling	Determine areas that don't have cooling	
Heating System Type	Determine fuel(s) used for heating	3.10.1
	Identify type(s) of equipment for heating	
	Determine the location of the distribution system for heating	
	Determine control system for the heating	
	Determine the thermostat set points and schedules if controlled by thermostat.	

	Determine heating system efficiency	
Cooling System Type	Determine fuel(s) used for cooling	3.11.1
	Determine the type of cooling system	
	Determine the cooling equipment efficiency	3.11.7
	Cooling Coil Airflow Testing - see diagnostics	
Air Distribution Ducts Characteristics	Identify the type of distribution system used to for the heating and cooling systems	3.12
	If ducted system, identify the location of heating and cooling ducts.	3.12.3
	Determine the value of distribution system insulation	3.12.4
	Duct Testing - see diagnostics	3.12.5
Mechanical Ventilation	Inspect for ventilation system obstructions. **Centralized Ventilation Testing - see diagnostics**	
Thermostat set-points and schedules	Record heating and cooling set point temperatures and schedules for each representative zone	
Hydronic Heating and Combined Hydronic Systems	Inspect piping of hydronic heating and DHW systems for presence and quality of insulation.	
	Collect nameplate data for boilers, domestic hot water heaters, pumps, controls	
Domestic Hot Water Heating	Determine type and source	3.15
	Determine location of storage tank	
	Determine capacity of the storage tank	
	Determine the Energy Factor or thermal efficiency of the water heater	
	Determine type of distribution	
	Determine the water distribution piping location and insulation	
	Determine recirculation control, recirculation pump horsepower and efficient rating	Table R3-46
	Measure recalculating system pipe location, length, and insulation thickness	
	Central DHW System diagnostic testing	
Solar Hot Water Heating Systems	If there is a solar hot water heating system, determine type of system.	
	Determine efficiency of solar system	
Interior Lighting	fixture type and quantity	
	lamp type per fixture	
	lamp W	
	lamp qty per fixture	
Exterior Lighting	fixture type and quantity	
	lamp type per fixture	
	lamp W	
	lamp qty per fixture	

Combustion Safety	**Combustion Efficiency Testing see diagnostics**
Elevators	Determine elevator type, age, and motor nameplate data
Appliances	Record general condition and nameplate data for all major appliances including clothes washers/dryers, dishwashers, refrigerators, freezers
Water Fixtures	Determine flow-rates for indoor water fixtures.

ATTACHMENT "E"

Equipment Specifications

HVAC				Water Heating				
Air Conditioners	**Sys-1**	**Sys-2**		**DHW**	**Sys-1**	**Sys-2**		
Outside Unit				Type				
Type				Fuel source				
Manufacturer				manufacturer				
Model #				model #				
Serial #				serial #				
Manufactured date				manufactured date				
Cooling capacity (kBtu/h or tons)				input rating (kBtu/h)				
Cooling airflow (cfm)				recovery rate (gal/h)				
Cooling efficiency				storage tank volume (gal)				
Quantity				Energy Factor				
Indoor Fan coil				Thermal Efficiency (over 100 gallons)				
Manufacturer				Quantity				
Model #								
Serial #								
Areas served by this system?								
Furnace	**Sys-1**	**Sys-2**		**Combined Hydronic Systems**	**Sys-1**	**Sys-2**		
Type				pipe length				
Fuel source				pipe location				
Manufacturer				pipe diameter				
model #				pipe insulation				
serial #				circulation pump				
manufactured date				circulation pump control				

heating capacity kBtuh								
heating airflow				**Pool / Spa Heaters**	**Sys-1**	**Sys-2**		
Quantity				Type				
				Fuel source				
Areas served by this system?				manufacturer				
				model #				
				serial #				
Boiler				manufactured date				
Type				input rating (kBtu/h)				
Fuel source								
Manufacturer				**Solar Thermal**				
model #								
serial #								
manufactured date				**Solar PV**				
heating capacity								
Dedicated Outside Air Systems (Ventilation)								
				Appliances				
				Equipment	**Dishwasher**	**Refrigerator**	**Washer**	**Dryer**
Exhaust Fans				Manufacturer				
Type				Model #				
Motor Horsepower				Serial #				
Cfm				Type				
Control				Fuel Type				
Areas served by this system?				Quantity				

ATTACHMENT "F"

Energy Modeling Input Assumptions Table

General		
	Occupied Square Footage	SF:
	Resident Population	Persons:
	Occupancy Schedules	
	Lighting Schedules	
	Receptacle Equip. Schedules	
Utility Metering		
	Space: Common Spaces	Utility / Master, Individual:
	Space: Whole Building	Utility / Master, Individual:
	Space: Whole building	Utility / Master, Individual:
	Space: Units	Utility / Master, Individual:
	Space:	Utility / Master, Individual:
Architectural		
	Wall Insulation	Type / R-Value:
	Exterior Doors 1	Type / R-Value:
	Exterior Doors 2	Type / R-Value:
	Windows 1	Type / U-Factor:
	Windows 2	Type / U-Factor:
	Roof Insulation	Type / R-Value:
Infiltration		
	Infiltration Condition	Tight, Leaky, Very Leaky:
	Infiltration Rate	Air Changes/Hour (ACH):
Distribution Systems		
	Hydronic heat	Type:
	Hydronic heat/chilled water	Type:
	Low pressure steam	Type:
	Force air (warm and/or chilled	Type:
Indoor Heating / Cooling		
	Heating Controls	Type (TRV, Dial, Programmable):
	Heating Occupied Set Point	Temperature (Degrees F):
	Cooling Occupied Set Point	Temperature (Degrees F):
	Programmable Setback	Temperature (Degrees F):
	Programmable Setback Time	Hours/Day:
	Fan Operation (continuous or intermittent)	

Boilers/DHW Generators

Boilers (Hydronic)	Type / Combustion Efficiency:
Boilers (Steam)	Type / Combustion Efficiency:
DHW Tanks	Type / Combustion Efficiency:

Exhaust Fans / Mechanical Ventilation

Bathroom exhaust fans	CFM per Fan:
Kitchen exhaust fans (ducted)	CFM per Fan:

Domestic Hot Water

Daily Usage/Resident	Gallons/Day:
Delivery Temperature	Temperature (Degrees F):
Return Temperature	Temperature (Degrees F):
Pipe Insulation	R-Value:
Shower Heads	Gallons per Minute (GPM):
Sinks	Aerators (Y/N):

Domestic Cold Water

Toilets, Common	GPF / Flushes per Day:
Toilets, Dwelling Units	GPF / Flushes per Day:

Lighting

Space	Type / Wattage
Space	Type / Wattage
Space	Type / Wattage
Space	Type / Wattage
Space	Type / Wattage
Space	Type / Wattage
Space	Type / Wattage

Appliances

Range	Usage per Yr:
Refrigerator	Energy Star (Y,N) / Usage per Yr:
Dishwashing	Energy Star (Y,N) / Usage per Yr:
Laundry	Energy Star (Y,N) / Usage per Yr:
Miscellaneous Plug Loads	Usage per Yr:

ATTACHMENT "G"

San Francisco Bay Area Affordable Multifamily Retrofit Initiative[8]

POST MEASURE INSTALLATION VERIFICATION, INSPECTION, AND TEST OUT REQUIREMENTS FOR PROJECT QUALITY ASSURANCE ("QUALITY ASSURANCE & VERIFICATION PROTOCOL")

I. Overview

This document outlines the general requirements for a quality assurance and verification (QA&V) process for projects participating in the San Francisco Bay Area Affordable Multifamily Retrofit Initiative. The QA&V process includes in-situ ***visual inspections*** to verify proper installation of new equipment and weatherization measures and, for some specific complex energy efficiency measures, ***performance test-outs*** to verify proper operation of the installed measure. The inspections and performance test-outs outlined in this standard are designed to ensure quality installation of the measures and to capture the projected energy savings associated with each energy efficiency measure.

II. Quality Assurance and Verification Provider

The QA&V inspections and performance test-outs will be performed by the project Energy Consultant, or other QA&V provider, as agreed upon between the Initiative administrators, building owner, and Energy Consultant. The QA&V provider is responsible for coordinating all QA&V efforts. These efforts include:

- Coordinating the inspections and test-outs with building owner and other 3rd parties assisting in the QA&V process (i.e. HERS raters)
- Addressing deficient, noncompliant equipment installations
- Compiling measure installation documentation
- Completing the final QA&V report
- Coordinating delivery of equipment operation manuals to the building owner

The Energy Consultant shall prioritize the recommended measures for performance test-outs. Prioritization parameters may include, but are not limited to the following:

- Cost of the installed measure
- Expected energy savings of the installed measure
- Cost of performing the performance test-outs

[8] The Initiative is a partnership of the City of San Francisco Mayor's Office of Housing, Enterprise Community Partners and the Low Income Investment Fund.

III. Quality Assurance and Verification Inspection Process

The QA&V plan is comprised of the verification inspection and, if applicable, a performance test-out of the installed measure. At a minimum, all projects will include on-site inspection to verify proper installation of each measure per specifications. The amount of effort devoted to the QA&V inspections and performance test-out depends on the types of energy efficiency measures installed, building parameters monitored during the energy audit, and other funding program requirements. Simple measures like, a building wide refrigerator replacement effort will require simple verification of installed equipment type and quantity. Complex HVAC measures such as boiler replacements, and hot water distribution loop re-design, will require a more involved QA process. Central ventilation systems that have been re-balanced may need to be commissioned to verify that the system is operating per design intent and that indoor air quality conditions have improved. Testing, balancing, and potentially more detailed commissioning of these systems will likely be necessary for HVAC retrofits and re-designs.

A. Verification Inspections

Verification inspections require on-site physical inspections. Verification inspections include.

- Photo documentation of the measure installation
- Recordation of actual nameplate data
- Documentation of the quantities of installed measures
- Verification of the correct location of installed measure
- Verification that the installed measure is operating

B. Performance Test-outs

Performance test-outs are completed to verify proper operation of equipment through all operating cycles and conditions. They typically are completed on complex HVAC measures associated with boiler and hot water distribution redesign, central ventilation related measures, and automatic lighting controls.

The following information sources can be used to partially document the performance test-out component of the QA&V process.

- HERS rater results and reports
- Equipment start-up checklists
- Testing and balancing reports
- Commissioning reports

If building parameters were monitored during the energy audit to inform the energy cost savings analysis, the same parameters should be used again to

inform engineering calculations, or energy modeling inputs, to verify energy savings for a specific measure. Measuring these parameters to verify performance may be considered a performance test-out. The Energy Consultant must decide what is to be observed and measured and with what confidence and precision. The Energy Consultant may need to consult a third party for performance test-outs of complex systems which fall outside the skill set of the Energy Consultant. The third party could be a commissioning provider; however, the cost of commissioning may be excessive for the building owner. Pre-functional checklists and functional performance testing of boilers and fans may be completed by the QA&V provider, if qualified and cost-effective.

Sample pre-functional checklists and functional testing used for commissioning HVAC systems can be obtained from the Portland Energy Conservatory Inc website[9]. If used, these tests can be tailored for each project's needs. These tests are more robust than start-up checklists and are intended to be used to verify that the system meets the design intent through all operating conditions.

C. Scheduling of Inspections and Performance Test-outs

The initial QA&V inspection will occur immediately after the installation of all the measures is complete and operating. Several on-site visits may be necessary in order to verify that all of the energy efficiency measures have been installed correctly. Schedule the initial inspections to occur as soon as possible after construction reaches the point where an inspection of a specific feature is possible. This will improve the likelihood that corrective action can be taken in a cost-effective and timely manner. Inspecting a specific feature (i.e. new wall furnaces or dwelling unit weatherization) at a critical point of the installation will allow for corrections in a timely manner and eliminate the need for the sub-contractor to backtrack to correct improper installations.

Another QA&V inspection may occur approximately twelve (12) months after the initial inspection. The extent of performance test-outs during the 12 month inspection will be prioritized based on budget constraints. The QA&V plan must include the level of performance test-out proposals for the 12 month inspection.

IV. Quality Assurance and Verification Plan

Each participating project will include a QA&V Plan in its energy audit report. While there will be similarities in every QA&V plan, it is expected that the QA&V plan will be tailored to each project's specific needs and the implemented energy efficiency measures. The QA&V plan at a minimum shall include:

[9] Portland Energy Conservatory Inc (PECI) is a Portland Oregon based firm that provides commissioning services and has a Functional Performance Testing guide book on their website for public use. The web site is http://www.peci.org/ftguide/ftg/index.htm

- Description of QA&V Plan
- Description of specific approach to QA&V for each sustainability measure implemented
- Description of inspections and performance test-outs for each measure at construction completion and 12-months
- Name and qualifications of the QA&V provider
- Cost of implementing the proposed QA&V plan

V. Contractor Responsibilities

The installing contractor is responsible for following all local, state, and federal codes and regulations. The installing contractor is also responsible for pulling all required permits. All mechanical and lighting equipment is to be installed per equipment manufacturer specifications and certified by an approved testing laboratory (UL, ETL, etc).

VI. Examples of QA&V Approaches

The examples below provide guidance on the QA&A process in an effort to verify quality assurance of installed measures and to help ensure the energy savings will be realized and sustained.

A. Envelope and Weatherization Improvements

Envelope and weatherization measures include air sealing to reduce infiltration, insulation installation, window replacements.

Where weatherization and air sealing have been implemented, QA&V provider shall inspect air sealing details, insulation installation, etc for quality craftsmanship and correct installation.

If loose fill insulation is installed in ceilings, walls, or floors, the QA&V provider shall obtain and provide to the Owner a copy of an installer certificate containing the following information:

1. address of the residence
2. date of installation
3. name and address of installer
4. amount, R-value, depth and type (including product name) of insulation installed
5. final R-value of insulation, including existing insulation values
6. area of the space (in square feet) insulated

If windows are replaced the QA&V provider will verify the following technical product data, and supply the information to the owner:

1. the number of windows
2. configuration by size and style (e.g.; 2'x4' horizontal slider)
3. area for each window configuration
4. NFRC rating of each window configuration
5. manufacturer name, window series, and model number
6. window manufacturer's warranty
7. contractor installation warranty (if offered)

If required by local, state, or federal weatherization programs, QA&V Provider will perform blower door diagnostic testing on agreed upon sampled units to verify reduction in unit to unit air leakage and leakage to exterior. The sampling protocol and testing details will be dependant on the weatherization program requirements.

Some remodels in low-rise residential projects trigger mandatory HERS diagnostic testing. HERS verification completed as part of the project is acceptable to meet program test-out requirements.

B. Ventilation System Measures

Potential energy efficiency measures to central ventilation systems may include repaired fan system and re-balancing of central ventilation and exhaust air systems. Photo documentation of a repaired ventilation system is required. Verification that the installed system meets the design intent and specified operating sequence is required. Typically, this includes verifying the air-flow is as designed, but may also require testing and balancing of the ventilation system and exhaust system if it is a balanced ventilation system.

C. Hydronic Heating System Measures

Photo documentation of equipment installation, equipment manuals, testing procedure documentation from a licensed contractor (C-6 and/or C-36), and boiler inspection are required. Please complete a visual inspection of equipment installation and obtain the following technical product data from nameplate, invoice, work order, or other sources.

1. equipment manufacturer, model number, capacities, and efficiency rating
2. total quantity installed
3. installation location
4. date of installation
5. name and address of contractor / installer
6. Inspect boiler system during heating season and observe at least one entire operational cycle and complete the performance test-out tasks provided below.

Verify that the installed system meets the design intent and specified operating sequence.

D. Other Heating Systems and Air Conditioning System Measures

Complete a visual inspection of equipment installation and obtain the following technical product data from nameplate, invoice, work order, or other sources:

1. Equipment manufacturer, model number, serial number
2. Equipment capacities and efficiency ratings
3. Total quantity installed
4. Installation location
5. Date of installation
6. Name and address of contractor / installer

Modifications to heating and cooling equipment in low-rise residential projects automatically trigger mandatory HERS diagnostic testing on HVAC equipment or distribution systems. HERS verification completed as part of the project is acceptable to meet program test-out requirements.

E. Domestic Hot Water System Measures

Complete a visual inspection of equipment installation and obtain the following technical product data with source cited:.

1. Equipment manufacturer and model number
2. Equipment capacities and efficiency ratings
3. total quantity installed
4. Total quantity installed
5. Installation location
6. Date of installation
7. Name and address of contractor / installer

F. Lighting Improvements

Verify the installation of lighting retrofits by visually inspecting the completed installation. Collect fixture, lamp, and ballast technical product data from the installing contractor and provide to owner. Provide a brief description of the completed retrofit including:

1. Location, type, quantity of pre and post retrofit lighting fixtures
2. Lamp manufacturer and model number
3. Lamp wattage and quantity per fixture
4. Ballast type, manufacturer, model number, and quantity per fixture type
5. Date of installation
6. Name and address of contractor/installer

Performance test-outs are not typically required for lighting retrofits.

G. Indoor Lighting Control Improvements

When automatic lighting controls have been added to a project, such as occupancy sensors and automatic daylighting controls, verify installation of specified controls and proper operation of the installed controls.

1. All control devices (photocontrols) have been properly located, field-calibrated and set for appropriate set points and threshold light levels.
2. Installer has provided documentation of setpoints, setting and programming for each device.
3. Simulate daylight conditions to verify dimming of the controlled lights, and simulate insufficient daylight to verify energizing the light fixtures.

H. Appliance Measures

When appliances have been replaced, physically verify the install in a sample of units and supplement this with invoices showing the total quantity and type of appliance. Document the inspected appliances with photos and copies of the invoices. Performance test-outs are not required for appliance retrofits.

VII. Failure to Install Specified Equipment

All new building components must comply with the specifications contained within the energy audit report or other written work order as provided to the QA&V inspector by a representative of the Initiative. If an inspection detects non-compliance with the specifications, the equipment shall be replaced with the correct specified equipment, or equivalent, and the energy savings estimates must be revised accordingly.

VIII. Performance less than predicted in the Energy Analysis

If an individual building component is found to be performing at a less energy efficient level than that which was recommended in the energy audit report, it will be necessary to take action to diagnose and remedy the problem to bring the building component back up to the efficiency levels assumed in the energy analysis. At both inspections, any discrepancies from agreed upon work that have been identified will be investigated and remedied as appropriate. The owner shall be notified of the inspection and test-out findings after each inspection.

IX. Building Benchmarking with Portfolio Manager

For direct metered projects the energy consumption of the building will be tracked with Environmental Protection Agency's on-line tracking tool Portfolio Manager. Portfolio Manager is an interactive energy management tool that allows you to track and assess energy and water consumption across your entire portfolio of buildings in a secure online environment. Monthly utility data will be submitted to Portfolio Manager for electricity, natural gas, purchased steam and chilled water, fuel oils, and water data.

X. Quality Assurance and Verification Report

The QA&V report shall include the following sections.

- Introduction to project and summary of QA&V effort
- List of measures installed, inspected, and test-outs for applicable measures
- Findings of QA&V process detailing any discrepancies between specified and installed equipment.
- Revised energy savings estimates based on QA&V process
- Conclusions and recommendations