MULTIFAMILY ENERGY AUDIT PROCESS GUIDE

Energy Efficiency and Conservation Branch

Multifamily Tool

Fiscal Year 2021

The purpose of the guide is to establish a process for conducting energy audits on multifamily dwellings within the District of Columbia. DOEE has recently implemented an owner contribution requirement for all rental properties. With this implementation, we would like to enhance our auditing process, so internal and external stakeholders are clear of our procedures and protocols when determining potential energy conservation measures for multifamily dwellings. This guide will be updated yearly to incorporate new federal and state mandates.

MULTIFAMILY ENERGY AUDIT PROCESS GUIDE

Information to Obtain from Building Owner/Property Manager prior to site visit:

- Age of building, previous rehab work, names of maintenance or service contractors that have routinely worked on systems in the building, utility company name and contact information, and utility billing history over 1-2 years;
- Building drawings and other key documents about the building and its systems; and
- List of current issues or concerns within the building to include identification of lead, mold, or asbestos.

The Energy Program Specialist is expected to meet with the owner to obtain the above information before requesting administrative staff to schedule a site visit to the property.

Classification of the multifamily building on data collection

- **Building size:** Low-Rise (≤3 stories) or Mid/High-Rise (>3 stories) building heights may impact the mechanical systems found within a MF building, as well as applicable codes/standards for fire safety, ventilation, etc.
- **Meter Configuration:** In master-metered buildings, all energy use is measured with one or more central meters. This can simplify the process of obtaining a utility bill history. However, it can also create a split incentive if building owners pay for the energy consumption, yet residents have significant impact on energy use (such as their thermostat set points). - In direct-meter configurations, all energy use is measured with a designated meter for each individual residential unit. This generally complicates the process of collecting a utility bill history due to resident turnover and the need to obtain billing access permission. - In mixed-meter configurations, one energy source like natural gas is centrally metered while another energy source like electricity is directly metered at each residential unit. This situation introduces elements of both the master-metered building and the direct-metered configuration.
- **Utility Billing Structure:** The format of a MF building's utility bill can have implications on the audit and potential ECMs. A building's recent utility bills should be reviewed to identify if Demand Charges are applied, or if Time-of-Use Rates or Block Rates are used. These billing features can increase the cost effectiveness of peak load reduction and load shifting in MF buildings.
- **HVAC:** Two common HVAC configurations in MF buildings are central plants or individual, residential unit-level space heating and cooling units. MF buildings with central plants will require appropriate modeling software or analysis tools for evaluation, and the replacement of such systems will require careful planning to ensure adequate space conditioning during tasks which greatly increase thermal loads such as window replacement (if the building is still occupied). Central systems will also tend to have more extensive distribution systems (pipes, ducts) which may offer significant energy saving opportunities for measures such as insulating, air sealing, balancing, and improved

controls. Individual HVAC systems can offer simpler, staged replacement opportunities, and can be more readily modeled in simulation software.

- **Hot water plants:** Two common configurations are central hot water systems and individual, residential unit-level water heaters. The same "central versus individual" implications for HVAC systems will also apply to water heating. For central systems, an important ECM to consider is improving the hot water distribution system with insulation or an energy efficient recirculation system.
- **Lighting:** Lighting systems in MF buildings are found within residential units, in common or public spaces within the building, and in exterior lighting systems. Lighting component upgrades (lamps, ballasts) are often cost effective in all three categories. Advanced lighting controls (e.g. occupancy sensors, photo sensors, timers, lighting reduction controls) should be evaluated particularly for public space lighting (interior and exterior). MF buildings with more extensive indoor common space or exterior lighting will usually offer greater energy savings potential. Adherence to minimum standards for light levels must be maintained. Likewise, building areas where the light levels exceed the lighting standards should also be noted.
- **Structural system:** Potential building structural systems include wood framing, steel framing, or concrete/masonry. The structural system of a building will be a strong determining factor in the types of envelope energy improvements that are feasible and realistic. While air sealing measures are always possible, the cost of adding insulation may not be reasonable. For instance in a wood or steel frame building, blown insulation will often be an option. However, in a concrete or masonry building, adding wall insulation may not be realistic unless other improvements are necessary to exterior or interior finishes.

Procedure for Sampling

- Sampling should include a cross section of units within the building.
- The audit should be completed on at least 10% of each unit type within the building. (If results are inconclusive, additional units should be sampled.)
- Units which are part of the audit sample should undergo a uniform scope of inspections and diagnostic testing.
- When sampling is utilized, energy and economic analysis of ECMs must be weighted appropriately to reflect how the sample relates to the actual numbers and types of residential units in the building.

The auditor should identify if additional personnel is needed to assist with sampling the units at the property. This request should be submitted in writing to the Program Manager promptly to ensure adequate staffing.

Information to Collect during the Audit

Heating, Ventilation and Air Conditioning (HVAC) System

1. Collect nameplate information (system type, capacity, fuel type, model number, serial number, manufacture date). Also estimate the remaining service life of the equipment, based on industry sources for expected life cycles of equipment.
2. Identify system efficiency levels: The efficiency level of existing systems can be field tested, taken from nameplate ratings, or possibly adjusted downward from nameplate ratings based on age and maintenance. The method used can have strong implications for the HVAC upgrade recommendations. The audit report must document the method used.
    a. For fossil fuel-fired equipment older than 10 years, combustion efficiency testing must be performed. While efficiency alone may not be a sufficient reason to replace equipment, the combustion efficiency test can signal a need for adjusting equipment controls or settings.
    b. For equipment that is not tested for efficiency, any assumptions or algorithms used for calculating efficiency reductions must be based on an industry reference and clearly stated in the audit report.
3. Combustion Safety: Evaluate supply air to mechanical rooms, CO testing of combustion equipment, and recommending CO detectors in the audit report.
4. Record information about HVAC controls, including features such as programmable, outdoor reset, zoning, etc.
5. Record information about HVAC distribution systems (ducts, pipes), including the location, presence/level of insulation, and air sealing features.
    a. If the system is ducted, duct leakage testing is recommended to determine the total amount of leakage and leakage to outdoors. High levels of leakage to outdoors yield a good energy savings opportunity.
6. Conduct overall visual inspection of all system components including equipment, distribution system, and registers or radiators.
7. COMMON ECMs:
    a. HVAC controls upgrades (e.g., programmable thermostats, thermostatic regulators)
    b. Duct air sealing; either mastic or aerosolized duct sealing
    c. Duct or pipe insulation
    d. System balancing
    e. Replacement HVAC: ENERGY STAR rated for residential systems; fuel-switching or dual fuel systems.

The HVAC data should be collected by the Energy Auditor who conducts the single-family emergency mechanical system post-inspections. This auditor should provide the information to the Multifamily Energy Auditor promptly after the site visit to ensure incorporation in the data collection form and TREAT.

Plumbing Equipment and Fixtures

1. Note the location, age, type, efficiency, general condition of water heaters and auxiliary systems (pumps, pressure tanks, etc. as applicable). Also estimate the remaining service life of the water heating equipment, based on industry sources for expected life cycles of equipment.
2. Record temperature settings on water heater(s), and specifically note un-safe settings which are either too high or too low.
3. Note presence of hot water recirculation systems. If present, document the control of the recirculation pump (e.g. continuous, temperature sensor) via inspection or interview with site staff.
4. Conduct visual inspection of visible supply and drain piping. Note evidence of leaks, corrosion, damage, or potential for freezing.
5. Conduct visual inspection of plumbing fixtures, faucets, and toilets. Note any leaky components (e.g. leaky faucet).
6. Document fixture, faucet, and toilet flow rates based on product age/specifications, or a field flow test.
7. Document presence/number of clothes washing machines, their age, and model number and specifications.
8. Document presence/number of dishwashers, their age, and model number and specifications.
9. Inspect outdoor faucets to look for complete shutoff and potential for freezing. Make sure outdoor watering practices are covered in your interviews with the building owner and maintenance staff.
10. COMMON ECMs:
    a. Replacement water heater(s): either ENERGY STAR storage tank systems; gas-fired instantaneous or tankless systems; or heat pump water heaters;
    b. Low flush or dual flush toilets; faucet aerators; low flow shower heads
    c. High efficiency dishwashers and washing machines (for residential systems this means ENERGY STAR qualified units)

Air Infiltration

1. Visually inspect the audited areas of the building inside and outside to identify evidence of air leakage. This will include but not be limited to windows, doors, common walls, exterior walls, utility penetrations, ductwork, window/wall air conditioners, ceiling/wall intersections, floor/wall intersection, basements, crawlspaces, slab edge, vents, rim joist, cantilevered floors, stairwells, elevator shafts, attic hatches, etc. Soiled insulation, carpeting, or wall finishes are also an indicator of air leakage.
2. Using a hand-held smoke tool around or in front of potential leakage areas is also effective in identifying air leakage locations.

3. Blower door testing: please see "Blower Door Testing" section below for a more in-depth discussion of considerations and decision-making regarding blower door testing in multi-family buildings.
4. COMMON ECMs:
    a. Air sealing using caulk, spray foam, gaskets, or solid blocking materials at the various air leakage sites listed above. Larger holes, and holes which appear consistently in a particular assembly throughout the building, take priority.

Insulation Levels

1. Inspect and document all areas of the building that are accessible including but not limited to: basement, crawlspace, floors over unconditioned space, walls, and attic/roof.
2. If areas are inaccessible (such as concealed walls or inaccessible attic spaces), determine with the building owner if areas can be opened up for viewing. This may involve an exploratory search that will require minimal damage to an existing wall, ceiling, or floor area.
3. COMMON ECMs:
    a. Additional attic insulation
    b. Blown insulation into uninsulated walls
    c. Additional foundation insulation

Windows and Doors

1. Document approximate age, condition, style, and ease of use.
2. Note cracked or missing glass.
3. Note air gaps around exterior doors, windows.
4. COMMON ECMs:
    a. Replacement of inoperable or broken windows
    b. Weather-stripping and door sweeps

Lighting and Electrical

1. Document existing lighting fixtures, number and type of fixture and lamps, broken out into these space groups:
    a. Common areas
    b. Private residential units
    c. Exterior
2. Document lighting controls, noting timers, photo sensors, occupancy sensors, etc.
3. Document switching patterns. Note inefficiencies as well as potential safety concerns.
4. Document any non-working lighting or receptacles which are observed.
5. COMMON ECMs:
    a. Lamp and ballast replacements
    b. Lighting controls for public areas and exterior spaces

Appliances & Miscellaneous Equipment

1. Document nameplate information including manufacturer, model, size, approximate age, condition, any available information indicating energy consumption.
2. Document type of fuel used for each appliance.
3. Check for proper operation of washing machines, dryers, range burners, ovens.
4. Check dryer venting and range hood operation, if applicable.
5. For miscellaneous equipment such as vending machines, document when machines are typically used (via staff interview).
6. COMMON ECMs:
    a. Refrigerator replacements to an ENERGY STAR qualified unit
    b. Converting public washing machines to cold water rinse only
    c. "Energy Miser" systems on vending machines to cycle them off during non-usage times

Air Leakage and Ventilation Air Testing Scope in Multi-Family Buildings

Major and minor air leaks should be identified during the audit process so that the leaks are dealt with during the retrofit/rehab of the building. Accurately estimating pre- and post- air leakage in multi-family buildings is complicated. Visual and tactile inspection will reveal large and obvious areas of infiltration, but blower door testing is necessary to more accurately quantify existing leakage rates, air leakage reductions, and consequently, energy and dollar savings. Typically a blower door test is used to determine where infiltration is occurring in an individual unit. Two types of blower door testing are available for measuring air leakage of a single residential unit in a MF building: guarded and un-guarded blower door tests. A guarded blower door test, done properly, will indicate the residential unit's total leakage to the exterior of the building. An un-guarded blower door test will indicate the unit's leakage rate to outdoors and adjoining units and other adjacent spaces. A guarded blower door test is resource intensive and logistically complicated. **DOEE requires the blower door test be completed for ALL multifamily projects.**

When Testing Should be Conducted

If an air sealing ECM is part of a retrofit project, an unguarded (at a minimum) blower door testing is conducted on a sample of the residential units, to quantify the pre- retrofit leakiness (see Sampling section above). Estimates of the expected air leakage reduction from air sealing ECMs should be based on clearly stated air sealing tasks. Assumptions used in the estimate of air leakage reduction must be clearly stated.

Common Areas

Air leakage testing in the common areas must also be addressed. How this is done will depend upon the size and configuration of these areas, as well as how numerous they are. If air sealing of

common areas including vestibules, corridors, laundry areas, etc. is an ECM investment, the air leakage testing can quantify air sealing potential.

Test-Out

Regardless of the type of testing performed or the building areas tested, post-retrofit "test-out" diagnostics should be completely consistent with the pre-retrofit testing setup and should be documented in the same manner

Evaluation of Ventilation

Air Ventilation air typically carries an energy penalty; however the post-retrofit building must comply with the applicable ventilation codes/standards for the program and building type (e.g. ASHRAE 62.1 or 62.2).

Options for evaluating ventilation air include:

- Direct air flow measurements,
- Acceptance of design values, or
- Acceptance of nameplate air flow values on equipment.

Direct measurement is recommended but requires more time and equipment, especially on central ventilation systems in larger MF buildings. However, larger central ventilation systems have also been shown to offer enormous energy savings in MF buildings if they are sized and balanced correctly.

At a minimum, auditors must evaluate the ventilation airflows using some appropriate method, and document this method. Auditors must also check the ventilation system(s) for operation, and any sign of obvious over- or under-ventilation in particular areas.

Duct Leakage Testing

Similar to blower door testing, duct leakage testing can offer valuable information in some scenarios but can also be complicated and time consuming to conduct. Accordingly, if duct sealing is to be a major ECM investment in a project, a sample of duct systems must be tested to quantify leakage to outdoors. This testing is a requirement however if ample documentation is submitted to the Program Manager and Branch Chief it may be waived if the duct system cannot be tested for leakage to outdoors based on the size or layout of the duct system.

To assist auditors in developing effective ECM specifications, DOEE strongly encourages the use of US DOE's "Standard Work Specifications for Multifamily Energy Upgrades." https://sws.nrel.gov/sites/default/files/sws_multifamily.pdf

Modeling Assumptions and Methodology

In developing the baseline model, auditors must follow these steps:

Clearly state assumptions and how building components which cannot be physically verified were addressed.

If individual residential units are being modeled, create a model variation for each major type of floor plan (e.g. a model for 3 bedroom units; a model for 2 bedroom units)

Air leakage (infiltration) rates should reflect outdoor air leakage only and should attempt to exclude air leakage between adjacent units. If only unguarded testing was conducted, estimates should be made about what proportion of this leakage was from outdoors (as opposed to adjacent residential units).

Calibrating the Baseline Model

Calibrating the energy model so it accurately describes the pre-retrofit building involves adjusting the software model in reasonable ways, such that the annual energy total estimates better align with historical totals. A model calibration may also be called a "true up."

It is recommended that the utility bill calibration bring the baseline model within 10% of actual utility bill history on a monthly basis. Otherwise, artificially high baseline model estimates can result in ECMs which appear to save more energy than they realistically will be able to achieve.

General guidelines for baseline model calibration include:

- Baseline model adjustments should not contradict field observations or data. E.g., do not change envelope insulation levels in the model to better align the energy totals with actual billing data, if the model already is using field-verified R-values.
- The baseline model and the utility bill history should both be based on the same annual weather profile. This will involve normalizing either the model or the utility billing history so the comparison in their annual energy totals is "apples to apples."

Even a basic calibration of the baseline energy model can be very helpful in gaining confidence in the accuracy of the model.

The Energy Auditor should submit the data collection sheet (completed in its entirety), TREAT files, and energy audit report to the Branch Chief and Program Manager for submission to US DOE forty five calendar days after the site visit(s) concludes.

DOEE has obtained approval to utilize TREAT as the modeling software utilize the below resources as well to assist when preparing the energy audit for multifamily dwellings:

http://psdconsulting.com/software/treat/treat-training-videos/

https://treat.freshdesk.com/support/home?group=treat&_m=knowledgebase&_a=view

MULTIFAMILY ENERGY AUDIT PROCESS GUIDE

http://psdconsulting.com/software/treat/

During the US DOE approval process the Multifamily Energy Auditor is expected to provide a thorough response to US DOE as it relates to any questions or comments they may have about the audit report submitted. The response should not contain grammatical errors or data that is not consistent with information previously provided. Once US DOE approves the multifamily audit report it is expected that if funding is available staff follow the process as outlined in the weatherization process flow.