Indoor environmental quality (IEQ) and energy retrofits in low-income apartments: Retrofit selection protocol

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1 Introduction

Approximately one third of the U.S. population lives in multifamily buildings. Multifamily residents often have below-average incomes and sometimes reside in poorly maintained apartments with elevated levels of harmful contaminants. The U.S. is embarking on an aggressive building energy retrofit program that provides the opportunity to simultaneously improve energy efficiency and indoor environmental quality (IEQ). Building owners and governmental agencies would benefit from a retrofit selection strategy that accounts for projected energy savings and IEQ impacts, as well as retrofit costs. This paper presents a unique approach for identifying the most appropriate energy and indoor environmental quality (IEQ) retrofits given the available resources and the initial conditions of the apartment.

2 Materials/Methods

The goal of this retrofit selection protocol is to provide a rational and repeatable method for selecting beneficial retrofit packages that save energy, improve IEQ and meet budget constraints. The retrofit selection protocol developed for this study identifies the candidate retrofits, estimates the energy and IEQ benefits per unit cost, and provides a ranked list of the most suitable retrofits. This selection protocol will be used to identify appropriate retrofits to be implemented in 18 apartments, six apartments in each of three buildings, in different California climates and seasons. The buildings selected for this study will have the following characteristics: subsidized housing, low-rise, older than 20 years, each apartment should be individually metered, and have an independent heating and cooling (if present) system.

3 Results

The retrofits considered by the protocol are classified into four main functional groups:

- Ventilation (e.g., air seal, install whole unit mechanical ventilation, upgrade local exhausts)
- Thermal comfort/heating & cooling (e.g., add insulation, replace heating or cooling device, seal and insulate HVAC system ducts, upgrade windows)
- Source control (e.g., replace combustion appliances with pilots or backdrafting issues, solve limited mold issues)
- Appliances (e.g., upgrade lighting or appliances, upgrade water heating system)

Four specific retrofit measures are recommended whenever feasible because their benefits are documented and they are either required by current standards or have limited costs. These retrofit measures are:

1. Air sealing; especially inter-apartment leaks
2. Mechanical ventilation to meet or exceed ASHRAE Standard 62.2 (ASHRAE, 2007):
    a. Whole unit; e.g., 150% of required value
    b. Local exhausts; both kitchen and bathroom(s)
3. HVAC system filtration; high-efficiency filter and bypass reduction
4. Water heating system; low flow showerhead and tank/line insulation

The remaining available resources per apartment are allocated to retrofits based on the outcomes of a benefit analysis of the candidate retrofits. The potential impact of each retrofit measure,

based on the apartment-specific conditions, is estimated in three basic categories: energy, indoor air quality (IAQ), and comfort. Each retrofit receives a score on a -3/+3 scale for each impact category and the single scores are then added to obtain a total benefit score. Subsequently, the total benefit score is divided by the expected cost of the retrofit to estimate the normalized total benefit score with respect to the investment (total score/$). Finally, the retrofit measures are recommended in order of decreasing normalized total benefit score until all the resources are allocated to maximize the anticipated improvements. Table 1 presents a few retrofits that simultaneously save energy and improve IEQ (IAQ and/or comfort).

Table 1. Retrofits simultaneously improving energy and IEQ (IAQ and/or comfort).

Retrofit
Seal leaks between apartments
Upgrade vented bath/kitchen exhaust fans
Replace pilot ignition combustion appliance with efficient electronic ignition unit
Add external wall/ceiling insulation
Replace unvented heating device with efficient sealed vented one

The impact scores are assigned based on the initial conditions of the apartment and on predictions of benefits. A building manager interview provides background information on apartment features. Next, the apartments are inspected, using a standard protocol, to obtain specific data regarding the equipment and devices present as well as to identify potential opportunities for improvement. During the inspection, selected diagnostic measurements are conducted, including apartment air-tightness, exhaust flow rates, and proper venting of combustion appliance.

The assignment of benefit scores is based on engineering judgment supported, when practical, by calculated estimates of energy or IAQ impacts. The energy benefits are evaluated using the Home Energy Savers (HES) webpage (http://hes.lbl.gov). The tool considers the initial condition of a residence and suggests retrofit measures that improve energy efficiency, with the associated estimated yearly savings and retrofit costs. For multifamily settings, the townhouse option is used with a high level of attic insulation if there is another apartment above the one of interest. The energy scores are given according to the expected yearly savings of the action.

The HES tool does not consider IEQ impacts. The potential IAQ benefits of some retrofits are evaluated with simple mass balance calculations using data collected from the diagnostics and values obtained from the literature. The IAQ benefit scores are assigned based on the expected concentration reduction of well-mixed contaminants compared to reported standards (CARB, 2008) or engineering judgment.

In addition to physical retrofits, the interventions include tenant education about maintaining IAQ, energy efficiency and comfort in their apartment as well as specific education related to the appropriate use of the implemented physical retrofits. The general education is provided with published material (e.g., HUD Healthy Homes brochure), while the retrofit-specific education is being developed as part of the current project. The full protocol document is available on the project website (http://arei.lbl.gov).

4 Conclusions

The available resources to perform energy and IEQ retrofits in apartments are limited. Therefore, entities involved in apartment retrofits need to identify how to most appropriately utilize the resources. The retrofit selection strategy presented addresses this necessity and attempts to capture energy, IAQ and comfort improvement opportunities. The selection protocol involves a predetermined set of retrofits and others selected based on the apartment's initial conditions and the expected energy, IAQ and comfort benefits. Given the many uncertainties and constraints, this protocol can be considered as a first step toward a comprehensive quantitative selection tool.

Acknowledgments

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5 References

ASHRAE. 2007. *ANSI/ASHRAE Standard 62.2-2007,* Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

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