Improving indoor environments and saving energy in older affordable apartments

An applied research project of the Lawrence Berkeley National Laboratory, Indoor Environment Group

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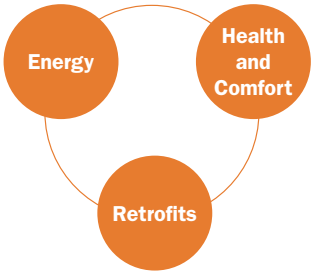
Summary

To reduce future changes to the global climate, California is increasing energy efficiency retrofits targeted to multifamily rental housing. These retrofits can degrade or improve indoor environmental conditions that affect occupant comfort and the risks of allergies, asthma, respiratory infections, and cancer. Currently, indoor environmental quality is rarely considered when retrofits are selected. This study shows that when indoor environmental quality concerns were addressed during energy retrofits of apartments, key comfort and health indicators improve.



Study Approach

- An audit and retrofit selection protocol was developed that considered effects of retrofits on energy, indoor air quality, and comfort
- Sixteen apartments from three buildings were retrofit, with retrofit measures selected using the protocol—the protocol resulted in a different mix of retrofits than using an energy-only protocol
- Measurements determined the effects of retrofits on indoor air pollutants, comfort conditions, humidity, and energy use

Common Problems

The table lists typical problems identified during audits and their effects.

Problem	Energy	IAQ	Comfort
Leaky envelope, windows and doors	●	●	●
Insufficient attic insulation	●		●
Old inefficient heating and air conditioning	●		
Leaky duct systems	●		
Incandescent light bulbs	●		
Old inefficient refrigerators	●		
Gas ranges with pilot lights	●	●	
Water heater backdrafting risks		●	
Single-pane windows	●		●
Inadequate kitchen range hoods		●	
Inadequate bathroom fans		●	
Low efficiency air filters		●	

Retrofit Scoring Example

Replacing a pilot-light gas range is a much higher priority than replacing the refrigerator when indoor air quality is factored into the decision:

Factor	Range	Refrig
Energy score	+1	+1
IEQ score	+2	0
Comfort score	0	0
Total Score	+3	+1
Installed Cost	$680	$740
Cost-normalized score per $1000:	4.4	1.4

- Energy: Both save ~$36/yr
- IEQ: The range replacement scores **+2** because it would reduce nitrogen dioxide and particles. No IAQ impact for the refrigerator
- Comfort: No impact for either

Key Retrofits and Average Installed Costs

Budget was $8,000 - $10,000 per unit ($12,700 per unit in Building 1 with utility program incentives). Retrofits needed to meet standards were selected first and then the remaining budget was allocated to the highest scoring retrofits. Kitchen range hoods were replaced in all three buildings; attic insulation was added in two buildings; and a few apartments had sliding glass door or window replacements.

- Envelope air sealing **$700**
- Attic insulation **$1200**
- Install energy recovery ventilator **$1600**
- Replace rooftop heating and AC units **$4100**
- Partial duct replacement and seal return plenum **$2200**
- Replace single pane sliding glass door **$2400**
- Replace single pane window **$800**
- Install intermittent or continuous bath fan **$900**
- Install kitchen range hood **$1200**
- Replace gas range with electronic ignition model **$700**
- Replace water heater with forced combustion model **$3300**
- Provide ENERGY STAR® refrigerator **$700**
- Install wall mounted particle filter **$800**

Initially, half of apartments received continuous mechanical ventilation systems; after indoor air quality measurements, continuous ventilation was added to three more apartments.

Findings & Recommendations

When retrofitting apartments to save energy, practitioners should take advantage of opportunities to simultaneously improve indoor environmental quality conditions that affect comfort and health.

- Many existing ventilation systems performed poorly.
- Placing indoor air quality and comfort on a level playing field with energy savings changed retrofit selections.
- In general, but not always, indoor environmental quality conditions improved after the retrofits.
- Indoor concentrations of volatile organic compounds, and carbon dioxide improved more when continuous mechanical ventilation was added. Particle concentrations improved most when air filter systems were installed.
- Based on the large year-to-year changes in energy use in non-retrofit control apartments, the study was too small for accurate measurement of energy savings.

When selecting retrofits, the effects on the apartment's energy consumption, comfort conditions, and air quality should all be considered.

Some recommended retrofit measures:

- Envelope insulation and window replacements can save energy by reducing heating and cooling costs AND improve comfort.
- Replacement of gas ranges that have pilot lights with electronic ignition models saves energy AND eliminates a continuous source of pollutants.
- Replacement of natural-draft water heaters with more efficient forced-combustion models saves energy AND reduces the risk of combustion pollutant back drafting.
- Improving apartment ventilation systems and providing particle filtration are high priorities because they offer large improvements in IEQ, even though they slightly increase energy use.

Project website with downloadable project papers: **arei.lbl.gov**

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