U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES OFFICE

Building America Case Study
Technology Solutions for New and Existing Homes

Evaluation of a Multifamily Retrofit in Climate Zone 5

Boulder, Colorado

PROJECT INFORMATION

Project Name: Evaluation of a Low-Rise Multifamily Retrofit in Boulder, CO

Location: Boulder, CO

Consortium of Advanced Residential Buildings
www.carb-swa.com

Building Component: Building envelope, lighting, appliances, water conservation

Application: Retrofit

Years Tested: 2012

Applicable Climate Zone(s): Cold, very cold

PERFORMANCE DATA

Cost of Energy Efficiency Measure (including labor): $3,300–$6,100 per unit with total complex cost estimate of ~$150,000

Projected Energy Savings: 27%–41% depending on unit location/orientation

Projected Energy Cost Savings: $154–$304 utility savings per year

In 2009, a 37-unit apartment complex located in Boulder, Colorado, underwent an energy retrofit to comply with Boulder SmartRegs Ordinance, a mandate that requires all rental properties to meet certain energy efficiency standards by 2018. The Consortium of Advanced Residential Buildings (CARB), a U.S. Department of Energy Building America team, worked with city planners and building owners to evaluate this program and recently completed a case study evaluating the effectiveness of a collection of retrofit measures.

In order to quantify the effectiveness of retrofits performed at this complex, CARB carried out several tasks, including: (1) modeling a sample of apartment units with the National Renewable Energy Laboratory's BEopt E+ 1.4 software to predict pre- and post-retrofit energy usage; (2) collecting tenant utility bills to assess actual energy use and savings; (3) performing spot audits on the property to evaluate the condition of building improvements one year after completion; and (4) performing a cost analysis on each retrofit measure.

Retrofit measures included attic and wall insulation, low-e windows, and energy-efficient appliances. Spot audits on nine of the 37 apartments revealed that the retrofit measures were essentially intact. However, CARB did discover a few changes, such as compact fluorescent lamps that had been replaced with less efficient incandescent bulbs and a few tenant-installed window air-conditioning units.

Modeling software predicts total (gas + electric) source-energy reductions ranging from 27% to 41% for the six apartments analyzed. Analysis of pre- and post-retrofit utility bills showed good agreement with the modeling. Total predicted gas and electricity savings for the six apartments were 61% and 27%, respectively. Actual gas and electricity savings were 58% and 30%, respectively.

The predicted energy savings associated with each retrofit measure are displayed in the following figure. This analysis indicates that improvements to the building envelope (insulation, infiltration reduction, windows) are the most effective in reducing energy costs.

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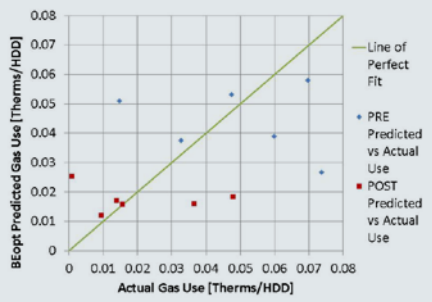
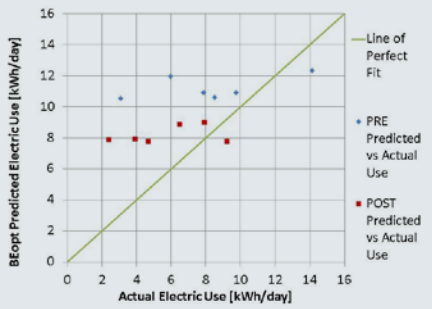
DESCRIPTION

Predictions from the modeling software (y-axis) were plotted against the actual energy use derived from the tenant's utility bill data (x-axis). Modeling predictions that match actual usage will reside around the line of perfect fit. Indoor relative humidity was maintained below the upper limit of 60% relative humidity for 99.86% of the time.



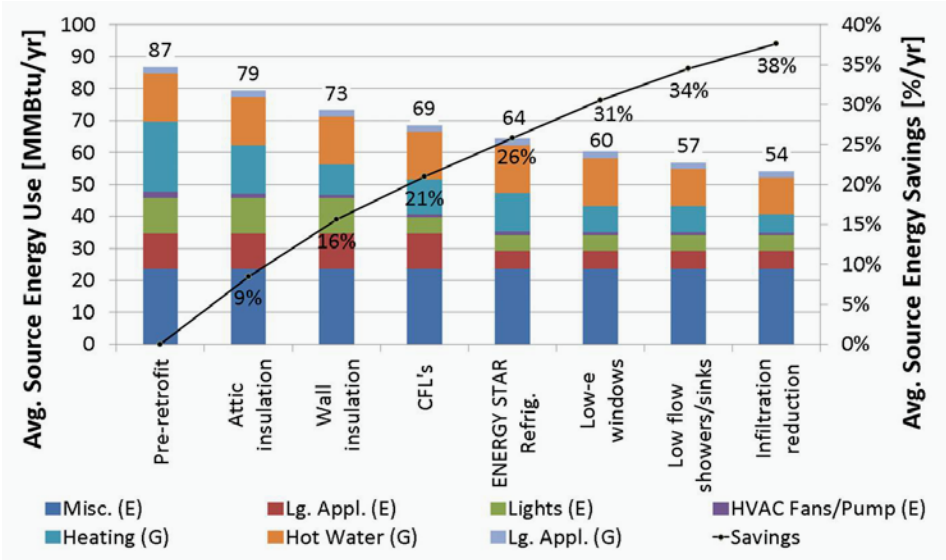
Gas use predictions (therms/heating degree day) are scattered both above and below the line of perfect fit. However, the model tends to underpredict pre- and post-retrofit total gas use.



Indoor temperature was maintained within comfortable limits of 74°F to 80°F for 91.5% of the monitoring period. Excluding the sub-74°F indoor conditions (lower than cooling set point temperature), the home was kept within the comfort zone temperature range for 99.3% of the cooling portion of the monitored period.

For more information, see the Building America report, *Predicted Versus Actual Savings: A Low-Rise Multifamily Retrofit in Boulder, Colorado,* at *www.buildingamerica.gov*

Image credit: All images were created by the CARB team.



The figure shows the predicted cumulative energy savings resulting from each of the energy retrofits implemented.

Lessons Learned

- On averaage, tenants in this complex can expect to save 26% to 41% in total building energy use.
- For a building with a similar configuration and pre-retrofit efficiency levels in a cold/very cold climate, added insulation, replacement of windows, and infiltration reduction prove to be the most effective building improvements.
- Energy modeling of the combined six units predicted total electricity and gas savings fairly well. However, predictions on a unit by unit basis were less accurate, indicating that occupant behavior significantly affected energy use.
- The energy modeling slightly underpredicted the total gas use (all six units combined) and significnatly overpredicted the total electrical energy use.

Looking Ahead

Of the approximately 28 million multifamily housing units in the United States, about 30%, or 9.7 million, are located in cold/very cold climates such as Boulder's. These numbers indicate the potential for significant energy savings if improvements can be implemented. Further studies should be completed to demonstrate the effectiveness of potential retrofits and to improve the accuracy of energy models used to assess these retrofits.

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