Kohl's Furthers Efforts To Maximize Efficiency

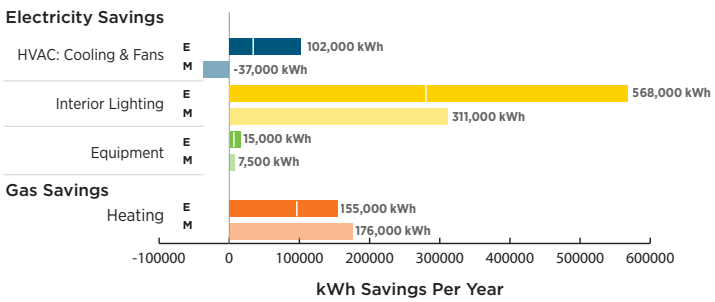
Kohl's Department Stores partnered with the U.S. Department of Energy (DOE) to develop and implement solutions to retrofit existing buildings to reduce annual energy consumption by at least 30% versus requirements set by ASHRAE/ANSI/IESNA Standard 90.1-2004[1] as part of DOE's Commercial Building Partnership (CBP) program.[2] The National Renewable Energy Laboratory (NREL) provided technical expertise. The retrofit solutions were demonstrated in a pilot project with the intent of applying successful measures in other stores.

Kohl's retrofitted a 17-year-old, single-story, 87,000-ft^2 store in Niles, Ohio, which was also designated as a DOE Better Buildings Challenge[3] showcase store. The retrofit was particularly noteworthy because Kohl's retrofitted the main sales floor lighting with light-emitting diode (LED) fixtures, which in the past have been limited to accent lighting applications.

Kohl's has a long history of increasing energy efficiency in new and existing stores by assessing savings from energy efficiency measures (EEMs) using energy modeling, testing them in the field, and widely deploying successful technologies. For CBP, NREL used EnergyPlus software[4] to model the Niles store and to calculate energy savings from new EEMs, starting with the DOE Advanced Energy Design Guide and Advanced Energy Retrofit Guide recommendations[5] to help Kohl's build the business case for new technologies.

The lighting and HVAC retrofits at the store, completed in November 2012, were expected to cut energy use by 36% versus ASHRAE 90.1-2004 annually while providing the same level of lighting and comfort to customers. Expected and measured energy savings by end use are shown in the graph below. Multiple electrical kilowatt-hour meters were installed to capture energy use by all building systems. Data from November 2012 through May 2013 (6 months) show 46% savings versus the code baseline, exceeding the expected 41% during that time.

Expected and Measured Energy Savings



E: EXPECTED 12 MONTHS, WHITE LINE MARKS 6 MONTH POINT IN EXPECTED
M: MEASURED 6 MONTHS

Kohl's uses an incremental assess-test-deploy process to reduce lighting energy consumption over time. *Photo Courtesy of Kohl's*

Project Type	General merchandise, retrofit
Climate Zone	ASHRAE Zone 5A, cool and humid
Ownership	Owner occupied
Barrier Addressed	Gathering trustworthy performance data for new technologies
Square Footage	87,000 ft^2
6 Month Measured Energy Savings (Versus ASHRAE 90.1-2004)	47% total 281,000 kilowatt-hours (kWh)/yr of electricity 6,000 therms/yr of natural gas
Simple Payback Period	< 5 yrs
6 Month Avoided Carbon Dioxide Emissions[6]	230 metric tons/yr
Retrofit Completion Date	November 2012

[1] ASHRAE 90.1: https://www.ashrae.org/resources--publications/bookstore/standard-90-1-document-history#2004

[2] CBP is a public/private, cost-shared initiative that demonstrates cost-effective, replicable ways to achieve dramatic energy savings in commercial buildings. Companies and organizations, selected through a competitive process, team with DOE and national laboratory staff who provide technical expertise to explore energy-saving ideas and strategies that are applied to specific building projects and that can be replicated across the market.

[3] DOE Better Buildings Challenge: http://www4.eere.energy.gov/challenge/home

[4] EnergyPlus: http://apps1.eere.energy.gov/buildings/energyplus/

[5] Available through the Commercial Buildings Resource Database: http://buildingdata.energy.gov/cbrd/

[6] EPA Greenhouse Gas Equivalencies Calculator: http://www.epa.gov/cleanenergy/energy-resources/calculator.html

Decision Criteria

The EEMs for the retrofit project needed to satisfy the same criteria as any investment of capital to meet Kohl's obligation to its shareholders. Customer experience was also a primary consideration. Any EEM that potentially impacted that experience was closely reviewed from branding and merchandising perspectives. The Niles store was selected as a retrofit project because the store was scheduled for replacement of the packaged rooftop HVAC units (RTUs), and Kohl's wanted to test the performance and business case of high-efficiency units it had not used before. The location also offered a good mix of weather conditions for testing store energy performance under heating and cooling conditions. As the store was built to the company's prototype specifications (a general store plan that is tailored to account for local circumstances), it was representative of a large group of other stores.

Economic

EEMs were judged based on their simple payback using a threshold that varied depending on the lifetime of the equipment in question, taking into account utility rebates, climate, capital costs, installation costs, operations and maintenance (O&M) costs, and energy costs, but not tax incentives. Additional details included:

- Although a relatively short payback period was deemed desirable, it was not the sole driving factor in decision-making.
- Kohl's pursues utility rebates where they are available, working with a third party that specializes in identifying and capturing rebate opportunities for its clients. According to Kohl's, utility rebates typically offset 15%–20% of the initial cost of a package of energy retrofits.
- A project-specific HVAC sizing calculation was done for the project (as it is done for all Kohl's projects) and included in the store plans. The retrofit HVAC system was sized to account for the reduced cooling load from the electric lighting EEMs. This strategy improved the business case for the retrofit project by minimizing capital expenditures and energy costs.

Branding

Maintaining a consistent look and feel on the sales floor across its stores is a high priority for Kohl's. Kohl's uses a drop (suspended) ceiling with recessed fluorescent lights on a regular grid, giving a uniform feeling. Changes to the lighting system or any prospective daylighting technologies had to take this into account, regardless of the technical implementation challenges. This consideration was a major factor when deciding whether to install LEDs on the sales floor.

Operational

Kohl's used full life cycle costing to evaluate energy-saving technologies. As a result, technologies with low maintenance costs were judged more favorably than they otherwise would be. For example, LEDs have lower maintenance costs because of their long lifetimes. Demand controlled ventilation (DCV) was relatively easy and inexpensive to implement and reduced the heating and cooling loads placed on HVAC equipment. Kohl's also used full life cycle costing when deciding to replace the store's HVAC equipment. Based on experience, Kohl's knew that the store's RTUs had reached the age when maintenance costs rapidly escalate and replaced them as a preventative measure.

Policy

Kohl's aims to be a leading environmentally responsible retailer with initiatives including waste reduction, engaging with the entire supply chain on sustainability issues, energy efficiency, and sustainable building design, construction, and operation practices. The company maintains a website dedicated to sharing its sustainability activities with the public. Achieving the ENERGY STAR® label for its stores is a major policy driver for Kohl's energy-saving investments; 790 of the company's 1,155 stores earned the label, meaning their energy performance was in the top 25% of comparable retail stores nationwide. The company earned an ENERGY STAR® Sustained Excellence Award in 2012. The company also joined the DOE Better Buildings Challenge, which aims to cut energy use by 20% company-wide by 2020, relative to a 2008 baseline. On the supply side, Kohl's has deployed solar panels on more than 135 stores in 12 states using third-party power purchase agreements, with an installed capacity of more than 44 megawatts. Photovoltaic panels were not installed at the Niles store.

Energy Efficiency Measures

The table on page 3 includes the full range of EEMs considered during the retrofit design process for application to the Kohl's store in Niles, Ohio, some of which Kohl's implemented in the retrofit project. Whole-building savings numbers include only installed EEMs and have been calculated relative to ASHRAE 90.1-2004. The business case and energy cost reductions from EEMs are not presented because Kohl's considers equipment capital costs and dollar savings confidential. Efficient electric lighting led to slightly higher natural gas use for heating in the winter; however, this increase was far outweighed by the lighting electricity savings. EEMs that are not applicable in all climates are marked with an asterisk (*). Climate-dependent EEMs should be evaluated to make sure they are a good match for the project location.

Energy Efficiency Measures	Implemented in This Project	Will Consider for Future Projects	Expected Annual Energy Savings kWh/yr
Lighting: 31% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
Replace 2 × 4 3-lamp 18-cell parabolic fluorescent troffers with 2 x 4 LED fixtures.	Yes	Yes	568,000
Replace 2 × 2 2-lamp troffers with LED fixtures.	Yes	Yes	
Relamp soffit downlights with LED retrofit lamps.	Yes	Yes	
Relamp track lights with LED retrofit lamps.	Yes	Yes	
Install an easily accessible maintenance lighting override button to prevent unnecessary overnight operation.	Yes	Yes	
Replace bare 2-lamp fluorescent strips in stockroom with 1-lamp strips with top reflectors.	Yes	Yes	
Replace outdoor floodlights and wall packs with LED fixtures.	Yes	Yes	10,000
HVAC: 5% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
Replace aging packaged HVAC RTUs with high energy efficiency ratio (EER) models containing variable-speed supply fans.	Yes	Yes	93,000
Use demand controlled ventilation controlled by store carbon dioxide concentration.	Yes	Yes	
Adjust the cooling set point to 74°F or other temperature deemed comfortable by customers.	No	Yes	
*Exhaust energy recovery ventilation on 1–2 units dedicated to delivering all the store's ventilation air.	No	Maybe	
*Evaporatively cool HVAC condensers.	No	Maybe	
Plug Loads: < 1% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
Completely turn off customer service computers and auxiliary equipment, Kohl's Kiosks, display lighting, office computers and equipment, and cash registers at night.	Partial Implementation	Yes	15,000

*Climate-dependent EEM

Energy Use Intensities by End Use

NREL used EnergyPlus software to evaluate the retrofit EEMs chosen for the Niles store retrofit by Kohl's to assess the feasibility of reaching the 30% energy savings goal. NREL also explored the impact of other EEMs not implemented by Kohl's such as exhaust air energy recovery and evaporative condensing to see how far Kohl's could stretch its savings in the future.

The energy models of the pre-retrofit and final retrofit design were based on the store's as-built construction drawings, knowledge about its occupant density, plug loads, real efficiency curves for HVAC systems, and other factors specific to Kohl's stores.

To assess whole-building energy savings, three EnergyPlus models were created, as described below. The energy use intensity (EUI), the annual energy consumption divided by the floor area, of each model is shown in the graph at the bottom of the page and compared to 6 months of measured energy use. Modeled energy savings by end use are displayed in the tables on page 5. All models were run with the observed weather at Niles.

Code Baseline

The first model represented minimal compliance with the prescriptive specifications of ASHRAE 90.1-2004 and ASHRAE 62.1-2004 for ventilation. The Niles Kohl's code baseline model had an annual EUI of 73 kBtu/ft² using a 30-year typical climatological dataset (TMY3). The modeling parameters were taken from Appendix G of Standard 90.1-2004 except that the orientation of the existing building was used and considered fixed.

Pre-Retrofit

The second model represented the Kohl's store prior to any retrofit work. The model results were compared with utility provider invoices to check the model's accuracy. Annual EUI was 62 kBtu/ft², 15% below ASHRAE 90.1-2004. These savings came from an interior lighting power density of 1.2 W/ft², versus a code-maximum of 1.5 W/ft², demand controlled ventilation, and more roof insulation than required by code (R-19 versus R-15). However, these savings were eroded by the diminished efficiency of the old packaged RTUs, which the energy model attempted to account for, as reflected in the greater cooling energy of the pre-retrofit model compared to the code baseline.

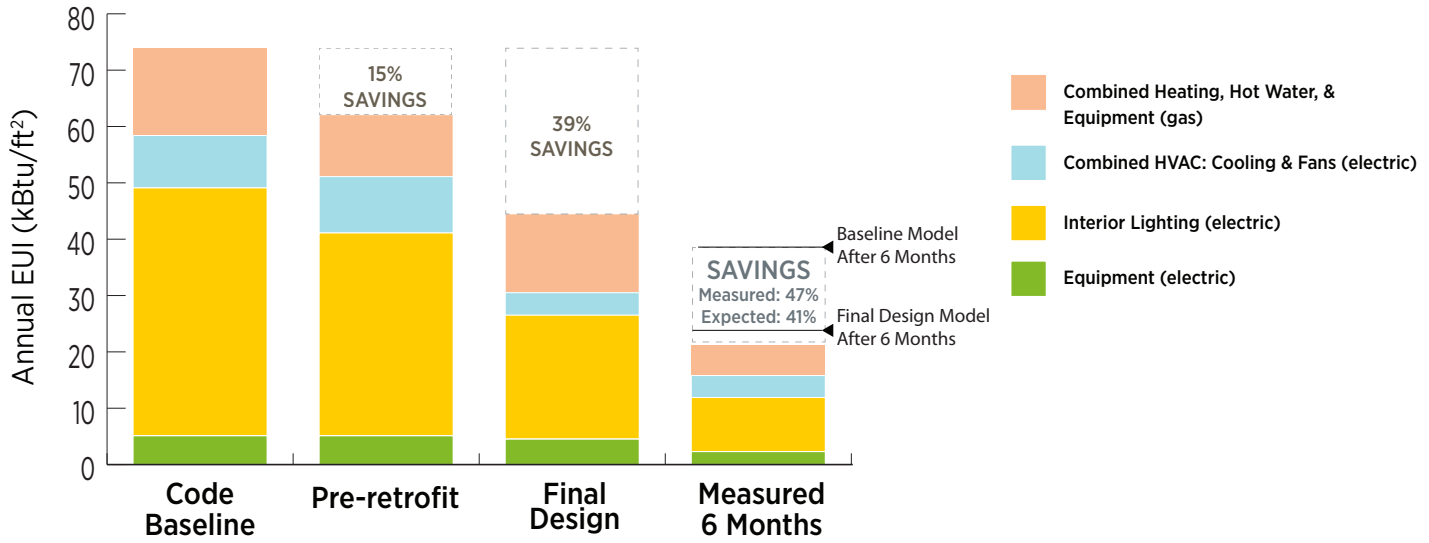
Final Design

The third simulation incorporated the EEMs selected for the retrofit. This model had an annual EUI of 46 kBtu/ft², an annual energy savings of 26% versus pre-retrofit, and 37% versus ASHRAE 90.1-2004. Savings were dominated by the interior lighting retrofit and replacement of the RTUs.

Measured Energy Use

Six months of measurements show energy consumption totaling 21 kBtu/ft². Comparison to the code baseline EnergyPlus model run with the observed outdoor temperature and relative humidity showed 46% savings, exceeding the final design model expectation of 41%. Savings was dominated by reduced natural gas consumption and interior lighting power.

Comparing Energy Use Intensity of Energy Models and Measured Energy Use



Annual Energy Use and Percentage Savings by End Use

	Code Baseline	Pre-Retrofit		Final Design		Measured (6 months)	
End Use Category	Annual EUI (kBtu/ft²)	Annual EUI (kBtu/ft²)	Percent Savings Versus Code Baseline	Annual EUI (kBtu/ft²)	Percent Savings Versus Code Baseline	6 month EUI (kBtu/ft²)	Percent Savings Versus Code Baseline (6 months)
Heating (gas)	16	11	31	14	13	5.4	56
Cooling and Fans (electric)	9.3	10	-8	4	57	3.9	-60
Interior Lighting (electric)	44	36	18	22	50	9.6	56
Equipment (electric)	5.1	5.1	0	4.5	12	2.3	12
Total	**74**	**62**	**15**	**45**	**39**	**21**	**47**

Building Energy Savings From Implemented EEMs by End Use

Electricity End Use Category

	Expected Annual Savings (kWh/yr)	Measured Savings (kWh/6 months)
Cooling and Fans	133,000	-37,000
Interior Lighting	568,000	311,000
Equipment	15,000	7,500
Electricity Total	**717,000**	**281,000**

Natural Gas End Use Category

	Expected Annual Savings (therms/yr)	Measured Savings (therms/6 months)
Heating	5,300	6,000
Natural Gas Total	**5,300[7]**	**6,000**

[7] Equivalent to 155,000 kWh

Notes: Electricity consumption for service hot water was relatively small and is not shown here.

Lessons Learned

As part of the Commercial Buildings Partnership work on the Niles store retrofit, Kohl's and DOE learned several lessons that can help other companies achieve similar results, as described below.

Go with the flow

Using variable frequency drives (VFDs) on supply fans in RTUs, which allows fans to ramp down when not needed, has proven to be a company-wide cost and energy savings strategy for Kohl's. Variable-speed fans are now standard in new construction and replacement units and Kohl's has even instituted a program to retrofit existing RTUs with VFDs, which pays back in just a few years. More than 5,000 Kohl's RTUs have been retrofitted with VFDs to date. At the Niles store, the HVAC units were old enough that they were replaced with units containing VFDs and modulating compressors. However, on a cautionary note, control challenges led to much higher than expected RTU energy use. Submetered data and information from the building's building automation system (BAS) must be carefully monitored to assess performance and achieve energy savings.

Kohl's replaced the store's aging RTUs with these new high efficiency units featuring variable speed supply fans and modulating compressors. *Photo Courtesy of Kohl's*

See the light

LEDs hold promise for reduced maintenance and energy costs for general retail lighting. Until recently, cost and light quality have presented barriers to their application except for accent and parking lot lighting. Consistent with its assess-test-deploy strategy, Kohl's did extensive pilot testing to make sure color temperature, illuminance, and glare were all acceptable before approving installation in this project. As a result, Kohl's cut interior lighting energy consumption by half compared to code.

Recognize the value of a multidisciplinary team

Kohl's realized that lighting, HVAC, building envelope, energy modeling, and plug load experts must sit at the same table and communicate regularly so that EEMs work well together and HVAC systems are properly sized. Merchandising and branding experts were also included because EEMs can impact the look and feel of a store. As a result, Kohl's was able to efficiently manage change in its retrofit package, ensuring that the concerns of all stakeholders were heard and addressed and that all team members aimed for the same goal.

Insist on lease language that facilitates energy savings

Kohl's stores occupy a mix of owned and leased properties. Commercial leases often specify that HVAC equipment replacement by the landlord is required only following total equipment failure. The result is that companies can be saddled with high energy bills caused by HVAC equipment that has not totally failed but that is very inefficient compared to newer replacement units. Based on historical data, Kohl's calculated that there was a strong business case for assuming responsibility in its leases to replace equipment after a fixed length of time to avoid escalating maintenance and operating costs. Even though the Niles store is owned by Kohl's, they felt this was an important lesson for when discussing retrofit projects.

Measurement facilitates good management

Building automation systems (BAS) traditionally have been designed to serve a narrow purpose — to turn lights and HVAC equipment on and off. However, with the increasing focus on energy efficiency, companies such as Kohl's have shifted to energy management systems (EMS) that serve the traditional BAS function and facilitate energy savings through long-term tracking, centralized collection, and data visualization. Kohl's data are monitored by a third-party partner that notifies stores or dispatches crews to take corrective action when problems arise, saving substantial energy and money.

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