Walmart is using highly efficient light-emitting diode fixtures to highlight its produce section. *Photo by Dennis Schroeder, NREL 32771*

Walmart — Saving Energy, Saving Money Through Comprehensive Retrofits

Walmart, the world's largest retailer, was founded in 1962 by Sam Walton. It owns and operates more than 11,000 retail units under 71 banners in 27 countries, and comprises 1.1 billion ft^2 of floor space. In 2009, Walmart partnered with the U.S. Department of Energy (DOE) to develop and demonstrate energy retrofits for existing buildings. The goal was to reduce energy consumption by at least 30% versus ASHRAE Standard 90.1-2007 or versus pre-retrofit energy consumption as part of DOE's Commercial Building Partnerships (CBP) Program.[1] The project presented here is the retrofit of a 213,000-ft^2 store in Centennial, Colorado, with energy efficiency measures (EEMs) across multiple building systems. It is part of Walmart's ongoing environmental sustainability program, which originated in 2005. The National Renewable Energy Laboratory (NREL) provided technical expertise in collaboration with Stantec, which provided detailed energy modeling services for the project. NORESCO and Mountain Engineering Partnership were responsible for the project measurement and verification. In addition to contributing to DOE's CBP program, the solutions installed and tested during the Centennial retrofit project will contribute to Walmart's Better Buildings Challenge commitment to reduce its U.S. energy use per square foot by 20% by 2020. These solutions are also expected to contribute significant benefits to Walmart's bottom line through reduced energy costs. The lessons learned from this study will be replicated at a large scale in Walmart stores and

[1] A DOE public/private cost-shared initiative to demonstrate cost-effective replicable ways to achieve dramatic energy savings in commercial buildings that are applied to specific new construction and retrofit building project(s) and that can be replicated across the market.

Project type	Retrofit
Building type	Walmart Supercenter with an auto center, garden center, pharmacy, grocery, and a McDonald's (big-box retail)
Climate zone	5B (cool and dry), ASHRAE 90.1-2007
Barriers addressed	• Measures must not interfere with customer experience or sales operations • Store must be open and operational 24/7 during the retrofit work
Square footage of project	213,000 ft^2
Energy savings	Electricity savings • 507,800 kWh (pre-retrofit baseline) • 2,811,900 kWh (ASHRAE 90.1-2007 baseline) Natural gas savings • 27,800 therms (pre-retrofit baseline) • 3,700 therms (ASHRAE 90.1-2007 baseline)
% energy use savings	• 19% (pre-retrofit baseline) • 34% (ASHRAE 90.1-2007 baseline)
Energy cost savings[2]	• $66,600 (pre-retrofit baseline) • $258,500 (ASHRAE 90.1-2007 baseline)
% energy cost savings	• 14% (pre-retrofit baseline) • 37% (ASHRAE 90.1-2007 baseline)
Expected simple payback time of retrofit measures	3-5 years (pre-retrofit baseline)[3] <2 years (ASHRAE 90.1-2007 baseline)
Annual avoided carbon dioxide emissions	1,097,000 lb/yr (pre-retrofit baseline)[4] 4,318,000 lb/yr (ASHRAE 90.1-2007 baseline)
Retrofit completion date	May 2013

[2] Calculated using a virtual charge of $0.091/kWh and annual average natural gas consumption charge of $0.7107/therm based on Xcel Energy: Secondary General Rates: Rate Summation on pages 20–23. Retrieved on October 16, 2014.

[3] Several retrofit measures were installed as first-time pilot projects that required additional engineering to be integrated successfully. The ultimate goal is for an overall simple payback of 3–5 years once those systems have been optimized for broad rollout.

[4] Calculated using the EPA Greenhouse Gas Equivalencies Calculator. Accessed February 20, 2015.

will set an example for other big-box retail companies throughout the nation.

The Centennial store includes several spaces with 24-hour operation: a grocery sales area, a general merchandise sales area, a garden center, stockrooms, receiving racks, and back offices that are mainly occupied by Walmart associates. Non-24-hour spaces include the service deli, the McDonald's restaurant, the vision center, the pharmacy lab, and the auto center. Refrigerated cases are located in the stockrooms and in the grocery sales area. The store includes an extensive electrical submetering system installed by NREL that has been collecting data from various store end uses since 2006. Data from this system were used to benchmark the performance of Walmart's new high-efficiency prototype store design and to calibrate the CBP baseline energy models. This data acquisition system was augmented to capture detailed performance data on the EEMs, most of which were installed in early 2013.

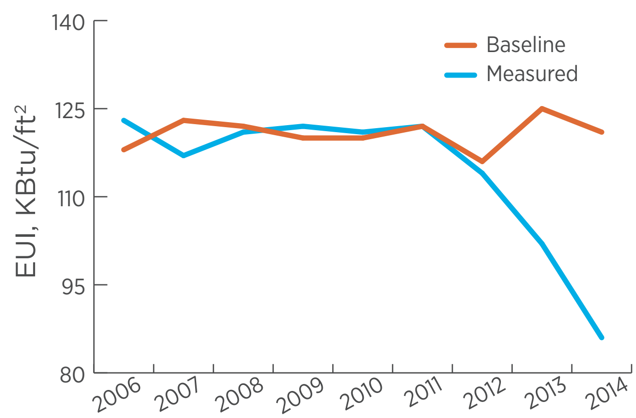
Walmart's building efficiency work is part of a wider Environmental Sustainability initiative—one designed to move the company to 100% renewable energy and reduce overall demand for energy. More specifically, the company aims to drive the production or procurement of 7 billion kWh of renewable energy by the end of 2020 and reduce its energy consumption per square foot by 20% by the end of 2020, versus a 2010 baseline across its global building portfolio. The company's strategy for achieving a 100% renewable energy supply follows a tiered approach including direct ownership, onsite generation facilitated by third-party power purchase agreements, and green power purchases (either wholesale or through utility green power purchasing programs). Walmart is currently the largest U.S. onsite green power generator, according to the U.S. Environmental Protection Agency's Green Power Partnership.

The remainder of this case study presents the measured whole-building energy savings and discusses the EEMs comprising the CBP retrofit project: the criteria for selecting the EEMs, a description of each, and the individual and aggregate energy savings. It also discusses lessons learned for each EEM.

Whole-Building Energy Savings

Utility bills from as early as 2006 were available to compare pre- and post-retrofit energy consumption. Energy models (described on page 5) were calibrated using the utility bills and submetered electricity data. The bills were also used to evaluate the energy savings provided by the EEMs implemented at the store. The statistical relationship between monthly electricity and gas consumption and outdoor air temperature (OAT) from 2006–2012 (pre-retrofit) was used to estimate baseline energy consumption (i.e., how much energy the building would have consumed in 2013 and 2014 if EEMs had not been implemented). This baseline served as a benchmark for post-retrofit performance. Figure 1 shows a graph of energy use intensity (EUI, which is the onsite whole-building energy consumption normalized by floor area) for 2006–2014. The figure includes the estimated annual baseline consumption (red), calculated using the measured monthly average OAT, and measured annual consumption (blue). For 2006–2012 the two lines are in fairly close agreement because these years preceded the major energy retrofits. The baseline did not agree perfectly with pre-retrofit energy use, because gas and electricity consumption variability was not perfectly explained by OAT. Comparing the measured whole-building energy consumption averaged over 2013–2014 (after the energy retrofits were implemented) to the pre-retrofit baseline showed a 24% reduction (18% in 2013 and 29% in 2014), which exceeded the 19% energy model-based prediction. The difference in savings between 2013 and 2014 reflected some of the early challenges of integrating new technologies such as refrigeration waste heat reclaim into the store. Interestingly, the drop in energy use in 2012 was apparently caused mainly by an unusually warm winter and an early spring rather than by actions taken to improve efficiency. The 24% average reduction in total annual whole-building energy use reflected a 15% reduction in electricity use (~650,000 kWh) and a 39% reduction in gas use (~36,500 therms) versus the baseline.

Figure 1. Baseline and measured EUI



Decision Criteria

The decision-making process was based on the following guiding principles:

- Maintain proven customer experience as the #1 priority.
- Protect customers: store and parking lot security was a key component of the project.
- Ensure the cost effectiveness of all EEMs.
- Keep the design simple, functional, and low maintenance.
- Emphasize the reproducibility of measures in other store retrofits.
- Maintain 24/7 store operations.
- Be proud of the quality of the final project.
- Maintain visual light levels needed for sales and signage.

- Respect the concerns of the store's third-party food services, vending machine, and ad placement partners.
- Maintain good produce quality.

Economic, operational, and policy considerations also contributed to the decision-making process.

Economic Considerations

Walmart has traditionally operated in the low-cost market segment; however, it has recently repositioned itself as a value leader. Significant economic factors are:

- Walmart is a large publicly traded company that emphasizes profits. It has chosen to focus on energy efficiency as a way to control operating costs and demonstrate environmental responsibility.
- Walmart selects EEMs with favorable simple payback periods of typically 3–5 years.
- Because Walmart often buys equipment directly from the manufacturers and can buy in volume, it can negotiate lower first costs that make EEMs quite economical.
- The DOE Better Buildings Alliance facilitates the banding together of big-box retailers to further increase the market pull for cost-effective energy efficiency technologies.
- By selling energy efficient products, Walmart can also provide consumers with opportunities to save energy and money.

Operational Considerations

Walmart updates its stores on a rolling 7-year cycle. Some building systems, such as lighting, are refreshed with each cycle. Others, such as mechanical systems, are updated on alternate cycles (i.e., every 14 years). The cycles are not fixed, and Walmart will move aggressively to integrate a beneficial new technology into its business.

- The entire operation revolves around maintaining customer comfort and satisfaction by meeting set points for temperature, lighting levels, and air quality.
- Each building system currently works independently with little or no regard for the other systems. One goal of this project is to optimize the operation as a whole system for cost and performance.
- Solid-state lighting fixtures for spotlights, refrigerated cases, exterior security, and parking lots have long lifetimes that can lower maintenance costs.

Policy Considerations

The guiding policy was shaped by the project's overarching goal: test robust, easily deployed EEMs in multiple building systems that save on energy use for Walmart stores supporting the company's 20% site EUI reduction by 2020 goal and that can be replicated by other big-box retail stores (see the sidebar on page 1).

Energy Efficiency Measures

Table 1 (page 4) lists the EEMs that were implemented in the project based on the economic, operations, and policy decision criteria mentioned earlier. The measure-by-measure impacts of the implemented EEMs are presented relative to the pre-retrofit baseline model to give a realistic estimate of savings. The individual EEM estimates were calculated by applying each EEM one at a time to the pre-retrofit model. This comparison was not possible for the ASHRAE baseline; many other building parameters besides the EEMs were different because original building design decisions were made before the retrofit was accomplished. Energy savings for each building end use is presented relative to both the pre-retrofit baseline and the code-compliant (ASHRAE 90.1-2007 baseline) model. The sum of the savings estimates for the individual EEMs may differ from those estimated for all EEMs applied together because some measures interact.

An NREL engineer checks the operation of the refrigeration system. *Photo by Dennis Schroeder, NREL.*

Table 1. Energy Efficiency Measures

		Expected Annual Savings			Simple Payback (Years)	Installed Cost to Achieve 3–5 Year Simple Payback
		$/year	kWh/year	Therms/year		
	Lighting					
L1	Perimeter light reduction: removed two lamps from each of the 111 4-lamp perimeter fixtures on the general merchandise sales floor. Lighting in the grocery perimeter fixtures was retained as is.	$4,500	61,500	(800)	<1	N/A
L2	Produce lighting upgrade: replaced 48 100-watt metal halide fixtures with 96, 12-Watt, 1000-lumen LED spotlights.	$2,700	46,200	(1,400)	>5	$8,100–$12,300
L3	Canopy downlighting upgrade: replaced 32 recessed 70-watt metal halide downlights with LED downlights and retrofit kits.	$900	10,100	–	>5	$2,700–$4,500
L4	Pharmacy canopy lighting upgrade: replaced 6 pharmacy canopy 70-watt metal halide fixtures with 36-watt recessed LED fixtures.	$200	1,900	–	>5	$600–$1,000
L5	Wall-mounted security light upgrade: replaced 17 175-watt metal halide lamps with 13 20-watt and 4 202-watt LED fixtures. The connected lighting load decreased from 3.4 kW to 1.1 kW. The lights operate an average of 11 hours per day.	$1,000	9,500	–	<3	N/A
L6	Garden center bulk storage area lighting upgrade: replaced 8 400-watt metal halide lamps with 8 202-watt LED fixtures. The connected lighting load decreased from 3.8 kW to 1.7 kW; the lights operate an average of 11 hours per day.	$900	8,900	–	<3	N/A
L7	Parking lot lighting upgrade: replaced 50 1,000-watt lamps with 87 263-watt LED fixtures. The LEDs exceed Illuminating Engineering Society of North America RP-20 minimum light levels. The site-connected lighting load decreased from 70 kW to 25.5 kW. The lights operate an average of 11 hours per day.	$12,000	124,400	–	>5	$36,000–$60,000
L10	Installed back-of-house occupancy sensors.	$200	2,000	(5)	>5	$600–$1,000
L11A	Garden center outside bag goods area: turned lights off during daytime (before retrofit the lights were on 24/7).	$1,400	16,700	–	<1	N/A
L11B	Garden center shade cloth area: turned lights off during daytime (before retrofit the lights were on 24/7).	$300	4,800	–	<1	N/A
	Lighting Subtotal	**$24,100**	**286,000**	**(2,200)**	**3–5**	**$72,300–$120,500**
	Heating Ventilation, and Air Conditioning					
H3	Use waste heat from 2 medium-temperature refrigeration systems to preheat ventilation air for the grocery sales area. The energy savings from this EEM depends on climate and should be evaluated carefully before implementing.	$10,000	(49,000)	18,800	>5	$30,000–$50,000
H7	Direct evaporative cooling of rooftop unit (RTU) condensers combined with indirect evaporative precooling of ventilation air on 6 of the 8 20-ton sales RTUs. The energy savings from this EEM depends on climate and should be evaluated carefully before implementing.	$7,500	49,900	(100)	>5	$22,500–$37,500
	HVAC Subtotal	**$17,500**	**900**	**18,700**	**>5**	**$52,500–$87,500**
	Refrigeration					
R1	Anti-sweat heater control upgrade: repaired and upgraded the existing control panel.	$10,300	123,500	(400)	<1	N/A
R2	Glass doors and LEDs added to medium-temperature dairy, deli, and beer cases, but not horizontal "coffin"-style cases. Calculated savings includes the negative impact of added anti-condensate heaters.	$14,200	68,600	12,700	>5	$42,600–$71,000
R3	Replace permanent split capacitor evaporator fans with electronically commutated motor fans in all walk-in freezers and coolers (59 motors total).	$3,100	41,900	–	>5	$9,300–$15,500
	Refrigeration Subtotal	**$27,600**	**234,000**	**12,300**	**3-5**	**$82,800–$138,000**
	Total					
	Total Post-Retrofit Versus Pre-Retrofit Baseline	**$69,200**	**520,900**	**28,800**	**3-5**	**$207,600–$346,000**