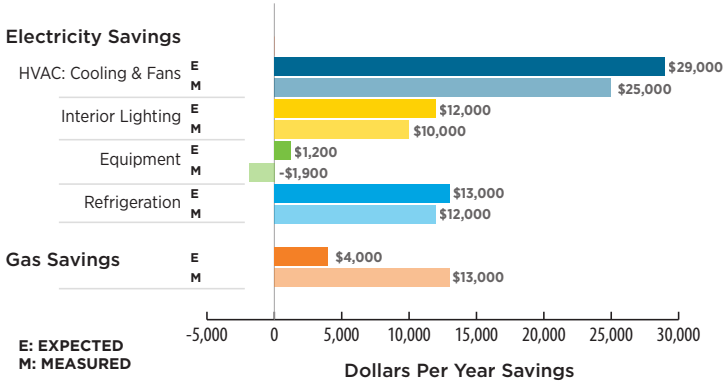
Whole Foods Market Improves Energy Efficiency in New Construction

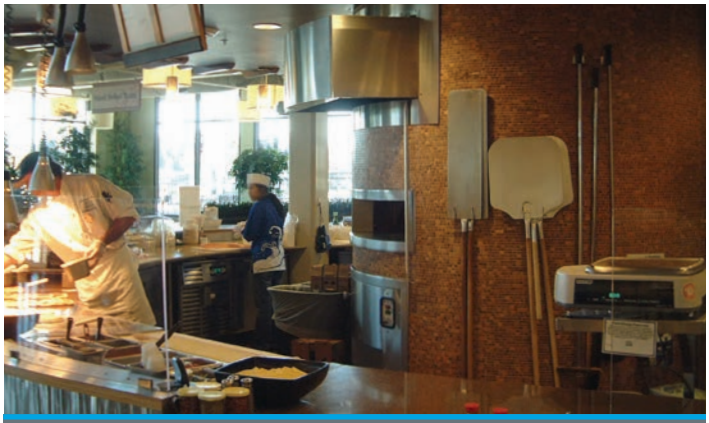
Whole Foods Market partnered with the U.S. Department of Energy (DOE) to develop and implement solutions to reduce annual energy consumption in new stores by at least 50% versus requirements set by ASHRAE/ANSI/IESNA Standard 90.1-2004[1] as part of DOE's Commercial Building Partnership (CBP) program.[2] The National Renewable Energy Laboratory (NREL) provided technical expertise.

The new Whole Foods Market store in North Raleigh, North Carolina, opened in March 2011. The store is a single-story, 40,000-ft^2 building, selling packaged food, fresh produce, general merchandise items, and prepared food. Whole Foods Market engineers and NREL staff brought new energy efficiency measure (EEM) ideas to the table starting with DOE Advanced Energy Design Guide and Advanced Energy Retrofit Guide recommendations.[3] Model-based expectations of energy savings using EnergyPlus[4] are shown in the "Expected and Measured Energy Cost Reductions" graph below.

From July 2012 through June 2013, total savings based on measurements from the store were 26% versus ASHRAE 90.1-2004. A significant challenge to reaching 50% savings was the large proportion of energy use going to loads such as cooking and refrigeration, which were outside the purview of ASHRAE 90.1-2004. There has historically been less focus on saving energy in those end uses compared to code-regulated items such as envelope, lighting, and heating, ventilating, and air conditioning (HVAC) systems. The CBP team formulated a set of baseline refrigeration system specifications analogous to ASHRAE 90.1-2004 and used them to generate an energy model to benchmark performance against. Typical equipment used in new Whole Foods Market stores was used to craft the equipment baseline.

Expected and Measured Energy Cost Reductions





The commercial kitchen at the Raleigh Whole Foods Market was a prime target for efficiency improvement. *Photo by Ian Doebber, NREL 18611*

Project Type	Grocery store, new construction
Climate Zone	ASHRAE Zone 4A, mixed-humid
Ownership	Tenant, but pays all utility bills
Barrier Addressed	How to identify the most energy-efficient refrigeration and HVAC equipment options
Square Footage	40,000 ft^2
Measured Energy Savings (Versus ASHRAE 90.1-2004)	26% total 760,000 kilowatt-hours (kWh)/yr of electricity 15,100 therms/yr natural gas
Cost Reductions (Versus ASHRAE 90.1-2004)[5]	$58,000/yr
Simple Payback Period	< 5 years
Carbon Dioxide Emissions Avoided[6]	600 metric tons/yr
Construction Completion Date	March 2011

[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] Available through the CommercialBuildings Resource Database: http://buildingdata.energy.gov/cbrd/

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

[5] Using $0.06/kWh and $0.83/therm utility rates provided by Whole Foods Market

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

Decision Criteria

At Whole Foods Market, EEMs needed to satisfy criteria similar to those used to screen other non-energy capital investments. North Raleigh, North Carolina was selected as the location for the new construction CBP project because the company's South region volunteered to design and build a store that would cut energy use in half versus code requirements if doing so was deemed economically and technically feasible.

Economic

EEMs were judged based on having a payback of 3–5 years, taking into account tax incentives, utility rebates, climate, capital costs, installation costs, operations and maintenance (O&M) costs, and energy costs. Additional economic factors included:

- Whole Foods Market pursues utility rebates where they are available and uses them to help guide where to pursue efficiency projects. Rebates were obtained from the local utility provider to help offset initial capital costs invested to lower energy use.
- Pilot funding of EEMs that do not meet the required simple payback threshold may be considered if other benefits are deemed sufficient to make the investment worthwhile. Whole Foods Market did not provide information on whether this consideration influenced the selection of EEMs for the North Raleigh project.

Branding

Environmental stewardship is a key element of the Whole Foods Market brand. EEMs installed at North Raleigh showed customers that Whole Foods Market acts in a manner consistent with its advertised image. Whole Foods Market prominently advertises its efforts to save energy in its stores.

Operational

Whole Foods Market took O&M costs into consideration when judging EEMs, both in terms of the business case for the technologies and their ability to deliver energy savings and services reliably. Whole Foods Market has developed strategies to share best practices for controlling and maintaining equipment from the North Raleigh project across the company's multiple regions. Regional store development leaders worked with local operations leaders to ensure EEMs would not negatively impact store operations.

Policy

Sustainability is a focus of Whole Foods Market's business practices, in terms of waste reduction, water conservation, and energy use in its stores and distribution chain. The company has had green building standards and design practices in place for years. CBP was an opportunity to dig into the details of how the stores use energy and dramatically cut energy use as a result. Whole Foods Market intends to reduce energy consumed per square foot by 25% company-wide by 2015, versus a 2008 baseline.

Whole Foods Market also maintains a policy of collecting feedback from customers to test assumptions about EEMs. For example, the company knew that putting doors on medium-temperature refrigerated display cases was a great way to save energy, but was concerned that the doors would inconvenience customers. By gathering anecdotal feedback from customers, the company found that this concern was unfounded and has installed this EEM in North Raleigh and elsewhere. Whole Foods Market also received positive feedback about using skylights to bring natural light into the sales area.

National policy issues that impact energy efficiency choices include tax policy that incentivizes efficiency investments such as the EPAct 179D federal energy tax deduction.[7] Building codes and standards also influence the decision-making process.

Whole Foods Market participates in the voluntary U.S. Environmental Protection Agency's GreenChill Advanced Refrigeration Partnership,[8] which encourages food retailers to use environmentally friendlier refrigerants, reduce refrigerant charge sizes, and eliminate leaks. These efforts reduce the impact of refrigerants on the ozone layer and climate, but are typically energy neutral at best and can even increase energy use.

Energy Efficiency Measures

The table on page 3 shows the EEMs considered during the design process, all of which Whole Foods Market decided to include in the North Raleigh store. Energy savings were estimated for combined packages of EEMs affecting each end use rather than for individual EEMs. This approach allowed Whole Foods Market to account for the interaction of EEMs in terms of their energy savings and to assess whether the payback time of the combined package satisfied the company's screening criteria, even if individual EEMs appeared to be too expensive. Whole-building energy savings estimates presented in the table were calculated relative to ASHRAE 90.1-2004 and included electricity and natural gas savings. The business case for the EEM packages depended on capital costs specific to Whole Foods Market and its suppliers, which the company did not share. EEMs that were not applicable in all climates are marked with an asterisk (*). Climate-dependent EEMs should be evaluated to ensure that they are a good match for the project's climate.

[7] DOE 179D Calculator: http://apps1.eere.energy.gov/buildings/commercial/179d/
[8] EPA GreenChill Partnership: http://www.epa.gov/greenchill

Energy Efficiency Measures	Implemented in This Project	Will Consider for Future Projects	Expected Annual Savings	
			kWh/yr	$/yr
Envelope: 0% Whole-Building Savings Expected Versus ASHRAE 90.1-2004				
*Add a vestibule to the store exit rather than only to the store entrance.	Yes	Yes	not modeled separately	not modeled separately
*Reduce the total glazing area and use more efficient glazing.	Yes	Yes		
Lighting: 9% Whole-Building Savings Expected Versus ASHRAE 90.1-2004				
Reduce total installed lighting down to 1 W/ft^2 using a combination of linear fluorescent, metal halide, and light-emitting diodes (LEDs)	Yes	Yes	382,000	23,000
Optimize the distribution of skylights and electrical lighting fixture selection to improve controllability in response to daylight.	Yes	Yes		
Control the lighting in the dry goods section by using an automatic bilevel switching strategy and reduce lighting during stocking hours.	Yes	Yes		
HVAC: 14% Whole-Building Savings Expected Versus ASHRAE 90.1-2004				
Decrease the total airflow rate throughout the sales floor from a typical 1 cfm/ft^2 to 0.6 cfm/ft^2 to reduce fan power consumption.	Yes	Yes	574,000	34,000
Control sales floor humidity using a main air handling unit featuring a desiccant wheel with waste heat regeneration and bypass.	Yes	Yes		
Refrigeration: 15% Whole-Building Savings Expected Versus ASHRAE 90.1-2004				
Use electronically commutated evaporator fan motors in refrigerated display cases.	Yes	Yes	628,000	38,000
Use LED fixtures instead of T-8 fluorescents in all low- and medium-temperature refrigerated cases and walk-in freezers.	Yes	Yes		
Add night curtains to open meat and produce multideck cases.	Yes	Yes		
Add doors to open medium-temperature dairy, deli, and packaged produce cases.	Yes	Yes		
Capture waste heat for air and service water heating.	Yes	Yes		
Use anti-sweat control strategies in combination with reduced sales floor dew point.	Yes	Yes		
Install electronic expansion valves and lower minimum saturated condensing temperature from 75ºF to 55ºF.	Yes	Yes		
*Use variable-speed fans to cool the low-temperature condensers.	Yes	Yes		
Kitchen: 5% Whole-Building Savings Expected Versus ASHRAE 90.1-2004				
Install side panels on all exhaust hoods to achieve a lower exhaust flow rate while capturing all the exhaust fumes.	Yes	Yes	277,000	17,000
Install demand ventilation sensors and controls to reduce the exhaust flow (and required make-up air) when there is no cooking.	Yes	Yes		

*Climate-dependent EEM

Energy Use Intensities by End Use

Energy modeling was an integral part of the design process for the new North Raleigh store. Each design decision was evaluated in the context of how it impacted the simulated store performance. If savings did not reach the goal, more work was done to identify additional opportunities to extend the savings as far as possible.

For the North Raleigh store, packages of EEMs were modeled for each building system separately and then together as an integrated whole-building package to identify energy and capital cost reduction opportunities from system interactions, such as using reclaimed waste heat for space and service hot water heating.

The energy model of the final design was based on Whole Foods Market's design and construction documents and information shared by the company about its occupant density, plug load diversity, real efficiency curves for HVAC systems, and other factors specific to the operation of its stores. Modeling accuracy was assessed by comparing output from an EnergyPlus model of the Whole Foods Market current specifications with utility bills from a representative store.

To assess whole-building savings for this case study, two energy models were created, as described below. The energy consumed annually by each model normalized by floor area (called energy use intensity or EUI) is shown in the graph at the bottom of the page and compared with a year of submetered energy measurements. All models were run with observed weather in North Raleigh.

By comparing models and measurements, NREL researchers identified deficiencies in how refrigeration, advanced HVAC, and kitchen exhaust systems were represented in EnergyPlus, leading to improvements that are now available to the entire design community.

Code Baseline

The first energy model represented minimal compliance with the requirements of ASHRAE 90.1-2004 for building envelope, lighting, and mechanical systems and ASHRAE 62.1-2004 for ventilation. Additional work was done to develop a refrigeration baseline, analogous to ASHRAE 90.1-2004 Appendix G, to capture the impact of energy-saving innovations. The North Raleigh Whole Foods Market code baseline model had an annual EUI of about 390 kBtu/ft^2.

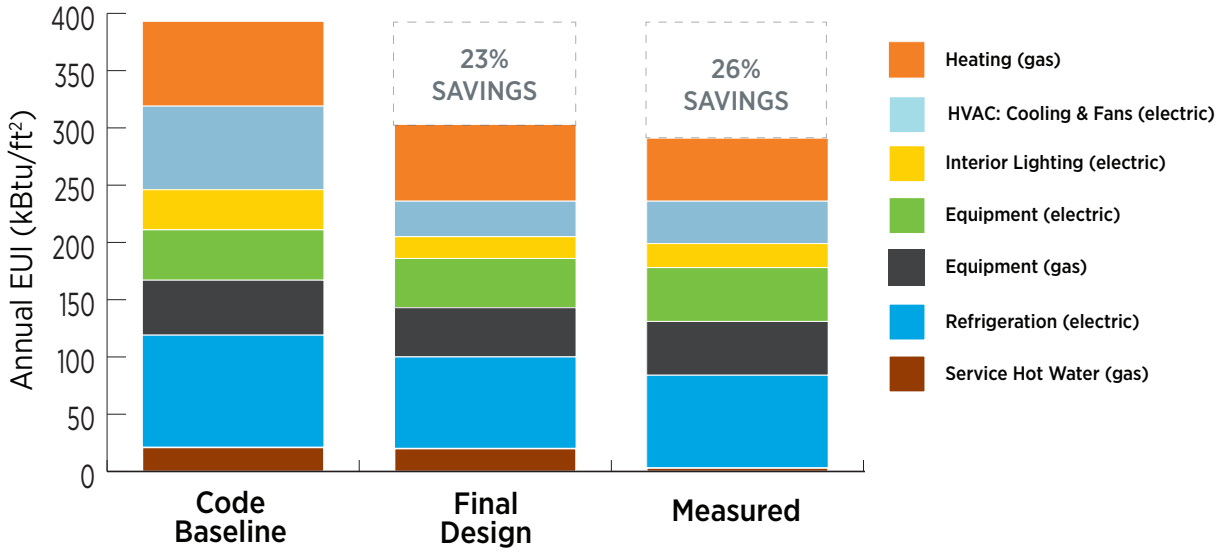
Final Design

The second model incorporated the EEMs selected for the North Raleigh new store design. This model had an annual EUI of about 300 kBtu/ft^2 and an annual energy savings of 23% versus ASHRAE 90.1-2004 requirements. Savings were expected primarily in lighting, due to Whole Foods Market's use of daylighting, and in HVAC cooling, because of the use of an active desiccant wheel with waste heat regeneration and bypass to control grocery humidity levels.

Measured Data

Energy measurements taken at the store from July 2012 through June 2013 show a total annual EUI of approximately 290 kBtu/ft^2, 26% below the ASHRAE 90.1-2004 baseline. The measurements show that 36% of the energy consumed was natural gas and 64% was electricity. The electricity was consumed by refrigeration (43%), plug loads (25%), HVAC (20%), and lighting (11%). Natural gas went to heating (52%), gas equipment in the kitchen and bakery (45%) and service water heating (3%).

Comparing EUI of Energy Models and Measured Energy Use



Annual Energy Use and Percentage Savings by End Use

End Use Category	Code Baseline	Final Design		Measured	
	Annual EUI (kBtu/ft²)	Annual EUI (kBtu/ft²)	Percent Savings Versus Code Baseline	Annual EUI (kBtu/ft²)	Percent Savings Versus Code Baseline
Heating (gas)	74	67	9	55	26
HVAC: Cooling and Fans (electric)	73	31	58	37	49
Lighting (electric)	35	19	46	21	40
Equipment (electric)	44	43	2	47	-7
Equipment (gas)	48	43	10	47	2
Refrigeration (electric)	98	80	18	81	17
Service Hot Water (gas)	21	20	5	3	86
Total	**393**	**303**	**23**	**291**	**26**

Building Energy Savings From Selected EEMs by End Use

Electricity End Use

	Expected Savings (kWh/yr)	Measured Savings (kWh/yr)
HVAC: Cooling and Fans	489,000	424,000
Lighting	193,000	165,000
Equipment	20,000	-32,000
Refrigeration	220,000	203,000
Electricity Total	**922,000**	**760,000**

Natural Gas End Use

	Expected Savings (therms/yr)	Measured Savings (therms/yr)
Heating	2,700	7,500
Equipment	1,900	400
Service hot water	400	7,200
Natural Gas Total	**5,000[9]**	**15,100**

[9] Equivalent to 146,500 kWh

Lessons Learned

As part of the CBP work on the North Raleigh store, Whole Foods Market and DOE learned several lessons, described below, that can help other companies achieve similar results.

Carefully commission energy submeters

Meters were installed by a third-party company in the North Raleigh store to measure the electricity and gas consumption of all end uses. However, calibration, documentation, and installation of the meters presented problems. These issues made it difficult to assess store operation until corrective measures were taken, which consumed time and resources.

Efficient equipment can lead to significant energy savings in grocery stores that offer hot prepared food items. *Photo by Ian Doebber, NREL 18615*

Use performance-based procurement

To select the most efficient HVAC and refrigeration systems for the North Raleigh store, NREL staff worked with the region's engineering partners and store development team to present a request for proposals to several interested manufacturers. The request for proposals specified the loads, outdoor conditions, and space conditions the equipment would need to meet. The manufacturers responded with the cost and energy use of their products, significantly streamlining Whole Foods Market's process of identifying and procuring the most efficient options.

> "We make it clear that the effort to improve energy efficiency makes sound business sense in addition to being the right thing to do."
>
> —Kathy Loftus
> Global leader of sustainable engineering and energy management, Whole Foods Market Corporation

Involve all players early in the process

Everyone involved in designing, building, and commissioning the building came together starting early in the design process. This move enabled the commissioning agent to provide a detailed review of the final store plans and make recommendations about the design and intended operation. Through the relationship established with the design team, the commissioning agent developed a detailed knowledge of the design and the team's intent, allowing him to catch problems during the store's commissioning that might have otherwise gone unnoticed. Measurement and verification could have benefitted from following this lesson. The measurement system should be specified as part of the store design process rather than after the fact, and the configuration of submeters should be included in the store construction documents.

Use equipment only as needed

Many companies run equipment and building systems such as lights and HVAC longer and at higher power than necessary to provide the required service. Whole Foods Market saved energy in North Raleigh by using automated controls that matched equipment function to load and that turned off or idled equipment when it was not needed. Examples included kitchen hoods, refrigeration condenser fan motors, refrigerated display case door anti-sweat heaters, and lighting. Careful inspection, calibration, and ongoing maintenance were required to ensure that potential savings in the building design translated into real energy savings.

An open and shut case

Putting doors on medium-temperature refrigerated cases, when coupled with LEDs, electronically commutated evaporator fan motors, and anti-sweat heater controls that respond to store dew point translated into major savings. Whole Foods Market also sought feedback about the doors from its customers, who responded positively to the change. The doors may also help explain the observed decrease in natural gas used for heating.

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