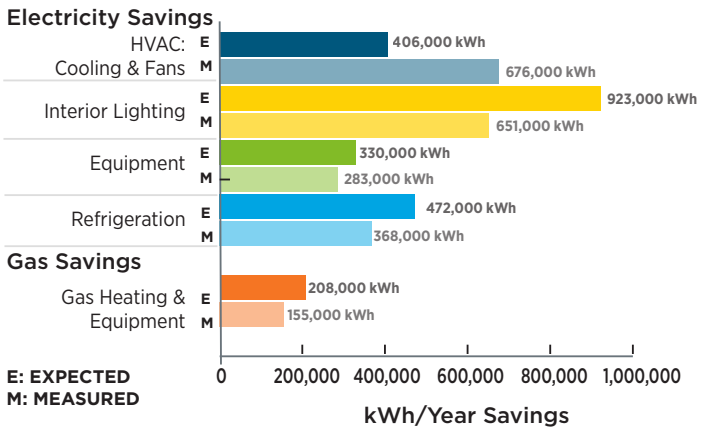
Target Pilots Energy Efficiency Measures for Broad Rollout in Existing Colorado Store

Target Corporation 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 90.1-20041 as part of DOE's Commercial Building Partnership (CBP) program.[2] The National Renewable Energy Laboratory (NREL) provided technical expertise.

Target chose a 9-year-old, single-story, 173,000-ft^2 SuperTarget in Thornton, Colorado, to test the strategies chosen to reach the goal. Target engineers and NREL staff brought new energy efficiency measure (EEM) ideas to the table starting with the DOE Advanced Energy Design Guide and Advanced Energy Retrofit Guide recommendations.[3] Retrofit construction was completed in November 2011. From June 2012 through May 2013, the store's total measured energy use from utility invoices was 33% below an ASHRAE 90.1-2004 baseline, slightly below the model-based estimate of 37% and exceeding the CBP goal. Expected and measured savings by end use are shown in the graph below. The strategies tested in this store are now being deployed selectively across Target's fleet of North American stores.

Since the 1990s, an in-house engineering team has steadily tested and implemented EEMs in Target store designs. NREL used EnergyPlus modeling software[4] to simulate EEMs for building envelope; lighting; heating, ventilating, and air conditioning (HVAC); refrigeration; and plug loads to estimate energy savings. Target subjected the EEMs to rigorous economic analysis informed by the energy simulations to ensure compliance with the company's business criteria.

Expected and Measured Energy Reductions



Target uses checkout stands and registers with a standby mode and turns them off during unoccupied hours. *Photo by Dennis Schroeder , NREL 19505*

Project Type	Combination general merchandise-grocery big box store, retrofit
Climate Zone	ASHRAE Zone 5B, cold and dry
Ownership	Owner occupied
Barrier Addressed	Perception that energy retrofit measures are uneconomical
Square Footage	173,000 ft^2
Measured Energy Savings (Versus Pre-Retrofit)	28%
Measured Energy Savings (Versus ASHRAE 90.1-2004)	33% total 2.0 million kilowatt-hours (kWh)/yr of electricity 5,300 therms/yr of natural gas
Simple Payback Period	< 5 Years
Expected Carbon Dioxide Emissions Avoided[5]	1,400 metric tons/yr
Retrofit Completion Date	November 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 Commercial Buildings Resource Database: http://buildingdata.energy.gov/cbrd/

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

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

Decision Criteria

For the Thornton retrofit, EEMs had to meet the same criteria as any investment of Target's capital to meet the company's obligation to its shareholders. Thornton was selected because the Denver area was a pilot site for several SuperTarget retrofit projects for the purpose of crafting a chain-wide retrofit strategy.

Economic

EEMs were judged based on net present value (NPV), taking into account tax incentives, climate, capital costs, installation costs, operations and maintenance (O&M) costs, and energy costs.

- Although positive net NPV was the primary economic criterion, measures that were found to pay back within 5 years (when all factors were accounted for) were viewed favorably.
- The cost and complexity of retrofitting any EEM into an existing building are generally higher than incorporating it into a new building design. This challenge was addressed by incorporating EEMs into a planned store renovation.
- Target aggressively pursues utility rebates where they are available and takes the availability and terms of rebate programs into account when considering where to invest in efficiency. Rebates were not available for this project.
- Target allocates some of its construction budget to innovation. The decision process involves a number of groups, including engineering, financial, and construction. The team weighs potential savings for a pilot store and for portfolio rollout against the cost when deciding whether to pursue a new technology. Target recognizes that additional investment in pilot projects may not meet financial hurdles but will pursue testing if a wider rollout of technology will be economical based on economies of scale.

Branding

A seamless customer experience is a major commitment at Target. An EEM such as retrofitting medium-temperature refrigerated cases with doors may be projected to save significant energy, but concerns about the impact of the doors on the customer experience prevented their deployment in this project.

The look and feel of the sales floor were also major considerations. Target 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 account for this concern.

Operational

Target emphasizes simplicity when saving energy. For example, insulation generally performs for decades as expected. Other EEMs, although potentially impactful, depend on moving parts or controls working properly to realize savings. Operational concerns were important in this project because the store needed to stay open during renovation and because modifications were being made to existing equipment. Examples of Target's approach in this area included:

- Maintenance and energy costs were reduced by installing long-lived solid-state lighting fixtures to spotlight merchandise.
- Ventilation airflow and associated energy use were optimized and good indoor air quality was maintained by bringing in a continuous 0.08 cfm/ft^2 of outdoor air.

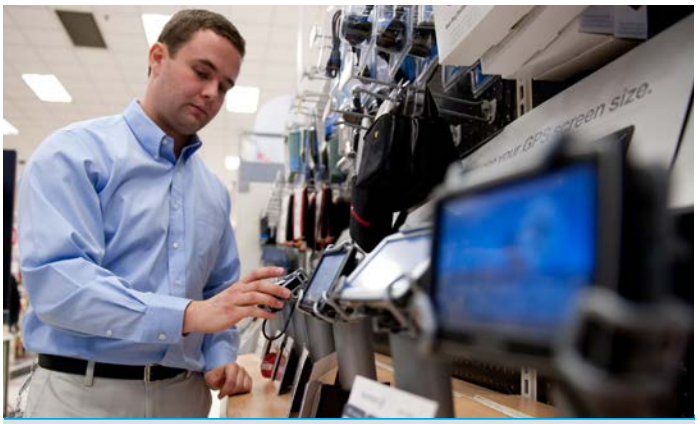
Policy

Sustainability is a focus of Target's business practices in its stores and distribution chain. EEMs support the following company goals for 2016:

- Reduce greenhouse gas emissions by 10% per ft^2 and 20% per dollar of sales.
- Earn the ENERGY STAR® label (top 25% in energy performance among comparable buildings nationwide) for at least 75% of its buildings.

Energy Efficiency Measures

The table starting on page 3 includes the full range of EEMs considered during the retrofit design process for application to the Thornton store. The EEM energy savings numbers were used by Target to screen EEMs against their economic criteria. Whole-building savings numbers include only EEMs selected for inclusion in the Thornton store design. HVAC savings were modeled by adding EEMs in a cumulative fashion. Savings include electricity and natural gas. EEMs that may not be applicable in all climates are marked with an asterisk (*) and should be evaluated based on a project's particular climate zone. EEMs are listed in order from greatest to least savings in each end use. HVAC EEMs were added to the pre-retrofit HVAC system sequentially. The EEMs shown in the table represent improvements made to the pre-retrofit building to increase its energy savings to 37% better than ASHRAE 90.1-2004.



An NREL engineer monitors plug loads in the electronics department. Target turns these products off at night to save energy. *Photo by Dennis Schroeder, NREL 19511*

Energy Efficiency Measures[6]	Implemented in This Project	Will Consider for Future Projects	Expected Annual Savings kWh/yr
Envelope: 0% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
*Increase roof insulation to R-25.	No	Yes	127,000
*Reduce infiltration in cart vestibule area.	No	Yes	10,000
Lighting: 15% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
Upgrade 114-Watt sales floor fixtures to 59-Watt fixtures.	Yes	Yes	591,000
Remove neon decorative lights from the sales area.	Yes	Yes	
Remove all backlighting from panels in the electronics section.	Yes	Yes	
Upgrade display and vendor lighting to light-emitting diode (LED) or higher efficacy fluorescent lamp/ballast combinations.	Yes	Yes	
Upgrade valance (concealed) accent lighting to lower wattage, higher efficacy linear fluorescent lamps on the sales floor.	Yes	Yes	
Upgrade lights in walk-in coolers/freezers to LEDs.	Yes	Yes	
Upgrade from 32-Watt T8 lamps to 25-Watt T8 lamps in offices and storage areas.	Yes	Yes	
Use daylight sensors to switch or dim electric lighting in vestibules.	No	Yes	
Reduce the number of auxiliary lighting fixtures, such as those installed above refrigerated cases.	Yes	Yes	
Improve distribution and reduce the number of fixtures in the back of house and office area.	No	Yes	
Turn off all sales floor lights during unoccupied hours.	Yes	Yes	35,000
HVAC: 9% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
1) Ventilate using a constant 0.08 cfm/ft^2 of outdoor air.	Yes	Yes	227,000
2a) In addition to 1: increase HVAC fan efficiency and control over the base case by changing from constant air volume to variable air volume.	Yes	Yes	246,000
2b) In addition to 1: widen temperature deadband set points throughout the store compared to the base case.	Yes	Yes	
*3) In addition to 2a and 2b: add energy recovery ventilators to the rooftop units that bring outside air into the building in the main sales, checkout, and grocery areas.	Yes	Yes	481,000
*4a) In addition to 2a, 2b, and 3: add evaporative condensing units to the HVAC system.	Yes	Yes	529,000
*4b) In addition to 2a, 2b, and 3: operate the grocery section at the traditional 53°F dew point temperature and the rest of the store at 55°F to 57°F dew point temperature.	Yes	Yes	

Energy Efficiency Measures[6]	Implemented in This Project	Will Consider for Future Projects	Expected Annual Savings kWh/yr
Refrigeration: 9% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
Replace all existing evaporator fan motors in cases with electronically commutated motors.	Yes	Yes	180,000
Add doors to open medium-temperature cases. and add variable frequency drives to condensers.	No	Yes	146,000
Allow condensing temperature to float in response to ambient and store conditions.	Yes	Yes	120,000
*Add evaporative condensing for the refrigeration system.	Yes	Yes	111,000
Use anti-sweat control strategies that modulate power based on sales floor dew point.	Yes	Yes	100,000
Add LED fixtures in all low- and medium-temperature refrigerated cases and walk-in freezers.	Yes	Yes	48,000
Allow suction temperature to float in response to ambient and store conditions.	No	Yes	29,000
Add night curtains to open produce cases.	No	Yes	29,000
Include strip curtains on all walk-in cooler and stocking doors.	Yes	Yes	18,000
Plug and Process Loads: 3% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
Set all computers to standby mode when not in use.	Yes	Yes	196,000
Use a load managing device on drink machines and turn them off at night.	No	Yes	
Eliminate personal printers, copiers, fax machines, and scanners. Replace with one or two multifunction print stations.	No	No	
Replace desktop computers with laptop computers.	No	No	
Identify EEMs for stockroom charging stations.	No	No	
Choose checkout stands and registers with standby mode and turn off cash registers and checkout stands during unoccupied hours.	Yes	Yes	
Turn off electronics products during unoccupied hours.	Yes	Yes	
Replace all cathode ray tube (CRT) monitors in the store with liquid crystal display (LCD) monitors.	Yes	Yes	
Kitchen: 0% Whole-Building Savings Expected Versus ASHRAE 90.1-2004			
Use high-efficiency kitchen equipment.	No	Yes	129,000
Consider close-proximity exhaust hood designs and temperature and particulate-driven control strategies to lower exhaust flow rates.	No	Yes	3,000

*Climate-dependent EEM

[6] The EEMs in this table have been applied to the pre-retrofit model (already 8% below ASHRAE 90.1-2004) to bring it to 37% savings versus ASHRAE 90.1-2004 rather than to the code baseline model.

Project Notes

As a matter of corporate policy, Target does not share the capital costs of EEMs or cost reductions from efficiency projects, or express energy savings in dollar terms. Therefore, the business cases for EEMs were not included in the EEM table. Several EEMs — many of them already standard Target retrofit measures — yielded immediate payoffs, such as performance-based ventilation, optimized dew point in the grocery section, anti-sweat control strategies, and plug load management. Additional notes about the project EEMs include:

Building Envelope

- Insulation will be added to the roof when the roof is replaced as part of regular maintenance.
- The cost of changing the vestibule design was a barrier in the energy upgrade. Target will consider this measure for new construction.

Lighting

- Target worked with vendors to identify options for LED or higher efficacy fluorescent ballast/lamp combinations for lighting its displays.
- The reduction of lighting fixtures, especially over refrigerated cases, was only partially implemented at the Thornton store out of concern that it would change the look and feel of the store.
- Target found the cost of completely replacing lighting fixtures to be a barrier in an upgrade and is using this EEM in new construction.

HVAC

- Target followed its standard practice of continuously ventilating at a reduced 0.08 cfm/ft^2 of outdoor air.
- The increase in HVAC fan efficiency and shift from constant volume to variable volume fan control were applied in the grocery area.

Refrigeration

- Night curtains were not added to open produce cases because Target had not finished weighing energy cost savings against Operations and Maintenance (O&M) costs.
- Doors were not added to open medium-temperature refrigerated display cases because of concerns about the impact of the doors on sales.
- Target did not allow suction temperature (the temperature of refrigerant after it leaves the refrigerated display cases and before it enters the compressors) to float because it was felt that further analysis and testing were required in Target stores.

Plug and Process Loads

- Target is currently researching load-managing devices to install on drink machines and working with its marketing team and vendors to reduce vending machine lighting loads. This research was not completed in time for inclusion in the retrofit project.
- Target was combining some office devices to save energy at the time of the retrofit. Therefore, the savings from this EEM were not included in the project total.
- Energy consumption was not the main criterion in Target's choice of laptop versus desktop computers. Target decided to stay with desktop computers for the retrofit.
- Stockroom chargers (for lifts, etc.) were not included in the energy savings calculation because of the insignificant savings potential compared to other EEMs.

Commercial Kitchen

- Target decided that further product research was required before upgrading kitchen equipment or exhaust hoods on the basis of energy savings.

In the greeting card section, Target upgraded the lighting fixtures from tungsten halogen MR16 to linear fluorescent. Target worked with its vendors, including the greeting card vendor responsible for this display, to install higher efficacy lighting. *Photo by Dennis Schroeder , NREL 19509*

Energy Use Intensities By End Use

Energy modeling was an integral part of the design process for the Thornton retrofit project. The impact of every design decision on store performance was evaluated by NREL using EnergyPlus modeling software. If savings did not reach the CBP goal, additional opportunities for energy savings were identified and assessed. At the same time, modeled savings were used by the Target financial team to screen EEMs according to whether they cleared Target's economic hurdles.

For some building systems, such as lighting, modeling an entire package of EEMs was appropriate for Target's decision-making needs. In other cases, such as HVAC, the business case was assessed by taking the pre-retrofit system and adding strategies in a cumulative fashion. For refrigeration, Target asked that measures be simulated individually.

The energy model of the store was made using Target's design development documents, construction drawings, and knowledge about its occupant density, plug load diversity, real efficiency curves for HVAC systems, and other factors specific to its stores.

To assess whole-building savings, three energy models were created, as described below. The energy consumed by different end uses in the three models, normalized by floor area (called energy use intensity or EUI), is shown in the figure at the bottom of this page. Modeled and measured energy savings by end use are displayed in the tables on the next page. All models were run with the observed weather from Thornton.

Code Baseline

The first energy model represented minimal compliance with the prescriptive specifications 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 to capture the impact of energy saving innovations. The baseline refrigeration system was modeled to have the same number and type of refrigerated cases as the retrofit, but to reflect an average system circa 2010, when the retrofit was being planned. The Thornton, Colorado, SuperTarget baseline model had an EUI of about 122 kBtu/ft^2.

Pre-Retrofit

The second model represented the store before renovation, and has an annual EUI of approximately 112 kBtu/ft^2, 8% below the code baseline. Submetered data, as-built plans, and utility bills were all made available by Target to facilitate model calibration and verification. Savings resulted from lower lighting power density, improved envelope, and more efficient HVAC equipment than required by ASHRAE 90.1-2004.

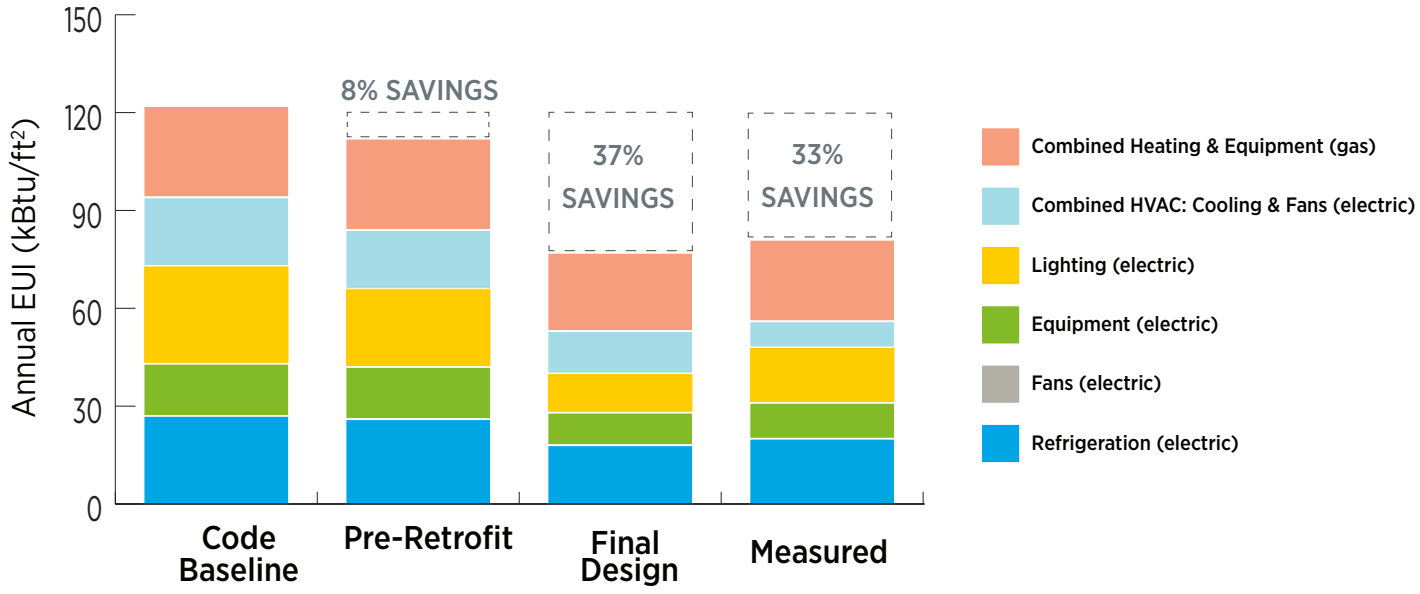
Final Design

The third version incorporated the EEMs implemented in the retrofit and summarized in Energy Efficiency Measures table. This model had an annual EUI of about 77 kBtu/ft^2 and annual energy savings of 37% versus the code baseline.

Measured Data

Annual measured EUI from June 2012 through May 2013 was 81 kBtu/ft^2, 33% lower than the ASHRAE 90.1-2004 baseline. The measured EUI was slightly higher than the Final Design because of higher lighting, plug load, and refrigeration energy use at night compared to the assumptions made during the design process.

Comparing EUI of Energy Models, and Measured Energy Use



Annual Energy Use and Percentage Savings by End Use

	Code Baseline	Pre-Retrofit		Final Design		Measured	
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	Annual EUI (kBtu/ft²)	Percent Savings Versus Code Baseline
Heating and Equipment (gas)	28	28	0	24	14	25	11
Cooling and Fans (electric)	21	18	14	13	38	8	62
Lighting (electric)	30	24	20	12	60	17	43
Equipment (electric)	16	16	0	10	38	11	31
Refrigeration (electric)	27	26	4	18	33	20	26
Total	**122**	**112**	**8**	**77**	**37**	**81**	**33**

Building Energy Savings From Implemented EEMs by End Use

Electricity End Use Category

	Expected Savings (kWh/yr)	Measured Savings (KWh/yr)
Cooling and Fans	406,000	676,000
Interior Lighting	923,000	651,000
Equipment	330,000	283,000
Refrigeration	472,000	368,000
Electricity Total	2,131,000	1,978,000

Natural Gas End Use Category

	Expected Savings (therms/yr)	Measured Savings (therms/yr)
Heating and Equipment	7,100	5,300
Natural Gas Total	**7,100**[7]	**5,300**

[7] Equivalent to 208,000 kWh/yr

Notes: Exterior lighting and electrical heating were not included in this project. Natural gas consumption for service hot water was relatively small and not considered in the study.

Lessons Learned

As part of the CBP work in Thornton, Target and DOE learned lessons that can help other companies achieve similar results. By pursuing an incremental, continuous improvement process that included energy savings goals and careful energy modeling throughout the design process, Target was able to design a retrofit to save significant energy. Several lessons that stand out are described in greater detail below.

Energy modeling adds value

All the EEMs presented here were subjected to a rigorous screening process; detailed energy modeling gave Target confidence that its investment in efficiency would be repaid quickly through cost savings. The energy model also set expectations for how much energy different building systems should use if operating as intended. Energy modeling today is often used after the fact to estimate energy savings of a final design. This approach misses the opportunity to improve the whole-building design by accounting for interactions between systems from the start.

Continuous improvement of electric lighting fixture efficacy is a cost-effective way to save energy with a high likelihood of sustained performance. *Photo by Dennis Schroeder, NREL 19506*

If it works, roll it out

A major goal of CBP was to achieve broad deployment of retrofit measures across the existing buildings in a company's portfolio. Based on NREL modeling to estimate savings in other regions, Target has implemented the Thornton EEMs in 13 U.S. stores and multiple Canadian stores in 2012 as part of scheduled remodels. Replication of pilot projects is a major priority for Target because of the potential to save money and to act in line with corporate sustainability policies.

> "Long after the Thornton renovation is complete, this collaboration will help us save energy in stores across our portfolio."
>
> —Scott D. Williams
>
> Group manager of mechanical engineering, Target Corporation

Bring all the actors to the table

Having a champion committed to reaching the project's energy goal was necessary but not sufficient to reach the project's goals. Because building systems interact through the heat they absorb or release, experts from different disciplines had to sit at the same table and communicate regularly. For example, HVAC engineers needed to understand the energy impact of lighting and miscellaneous electrical load EEMs to properly size mechanical systems. HVAC and refrigeration designers needed to coordinate to make sure the sales area was comfortable and that temperature and humidity were controlled by the air handling unit, where it could be done efficiently, rather than by the refrigerated display cases. In addition, promising EEMs may not be approved unless a company's merchandising and branding experts are included in the decision-making process and their concerns addressed.

Start simple

When it started to focus on saving energy 20 years ago, Target considered simple, robust strategies such as high-efficiency electric lighting, insulation, and exterior shading. Turning equipment off when it is not needed and broadening set points pay back immediately, often with significant energy and cost savings. Target also identified HVAC fan speed control as a big opportunity to save energy over the entire year. Once it established a set of reliable EEMs, Target began to pilot test other more complicated EEMs and eventually incorporated them into prototype designs (a standard store design that is modified to account for regional differences in climate, for example) for portfolio-wide replication when the business case was proven with solid performance and cost data. Something as simple as clearly documenting the configuration of an energy submetering system can pay off when the time comes to analyze performance data for different building systems.

Double check assumptions

Large stores use temperature setback and aggressive lighting reduction to save energy at night. However, the design team needs to consider the possibility of 24-hour occupancy for stocking and cleaning, which can require lighting and space conditioning that are necessary but reduce expected savings.

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