11. Facility Type: Supermarkets and Grocery Stores

Revised January 2008

11.1 Challenges and Opportunities 2

11.2 Energy Use Profiles 3

11.3 Technical Recommendations 4

- Retrocommissioning 5
- Lighting 8
- Load Reductions 11
- Air Distribution Systems 15
- Heating and Cooling Systems 16

11.4 Financial and Implementation Issues 17

Bibliography 17

Glossary G-1

11.1 Challenges and Opportunities

Energy is increasingly joining the ranks of top concerns for supermarket owners and facility managers. Supermarkets are the most electricity-intensive type of commercial building, using an average of about 50 kilowatt-hours (kWh) of electricity. They also use 50 cubic feet of natural gas per square foot (ft^2) per year. At an average annual energy cost of more than $4 per ft^2, energy expenses represent the most significant portion of the annual operating budget after labor costs for the grocery retail sector. Because the profit margins of supermarkets are so thin, on the order of 1 percent, the U.S. Environmental Protection Agency (EPA) estimates that $1 in energy savings is equivalent to increasing sales by $59.

Merchandising trends are pushing grocery stores to become even more energy intensive as stores are carrying more fresh-food products, frozen-food aisles are expanding, food-safety temperature requirements are tightening, and demand for prepared food is growing. But this sector also offers some of the most cost-effective and rewarding opportunities for energy savings, not only by improving system efficiency and reducing unnecessary energy use but also by reducing loads at peak times during the day, when energy prices are highest. Here are the overall benefits that improved energy efficiency can provide:

- *Increased profitability.* Energy savings are reflected in a company's profit-and-loss statement as reduced operating costs, which directly increase profitability. Total annual energy costs to operate a supermarket are usually equivalent to net profit: Both are between 1 and 2 percent of sales. Therefore, a 10 percent reduction in energy costs can increase net profit by as much as 16 percent. For a major chain, efficiency improvements that cut energy costs by 10 percent could yield tens of millions of dollars in added profit.
- *Reduced vulnerability to energy price fluctuations.* Energy prices may be sensitive to numerous external factors, including major weather events and changes in national and state regulations. For some regions, the potential for utility deregulation also lends uncertainty to future energy costs. Reducing a facility's total energy consumption can soften the impact of energy price fluctuations.
- *Increased sales.* Improving the energy efficiency of a building usually involves upgrades to the lighting and HVAC systems. By creating a more pleasing shopping and working environment, these upgrades can also attract and retain more customers, leading to an increase in sales.
- *Reduced spoilage.* Upgrades to refrigeration and lighting systems can reduce spoilage of perishable goods while also saving on energy bills.
- *Enhanced public image.* With growing concerns over global warming and other environmental issues, many supermarket owners want to demonstrate to customers that they are responsible environmental stewards. Supermarket owners can upgrade their buildings to be more energy efficient as a way to achieve this goal.

The impact of rising energy costs and growing concerns about global warming are leading food sales organizations to take action. Hundreds of grocery stores, including national and regional chain stores as well as independent grocers, are participating in the EPA's ENERGY STAR buildings program. For example, Hannaford Bros. Co. received national recognition as an ENERGY STAR Leader in 2006 by achieving an average ENERGY STAR energy performance score of 75 or better across its portfolio of stores. Hannaford also earned ENERGY STAR

labels for 10 of its stores in Maine in 2007 by implementing upgrades and increasing energy awareness among staff; its annual energy savings is approximately $452,000. Hannaford is able to use ENERGY STAR's rating system not only to earn public accolades but also to compare its stores' performance to that of similar stores nationwide and to track performance within the company's portfolio over time.

11.2 Energy Use Profiles

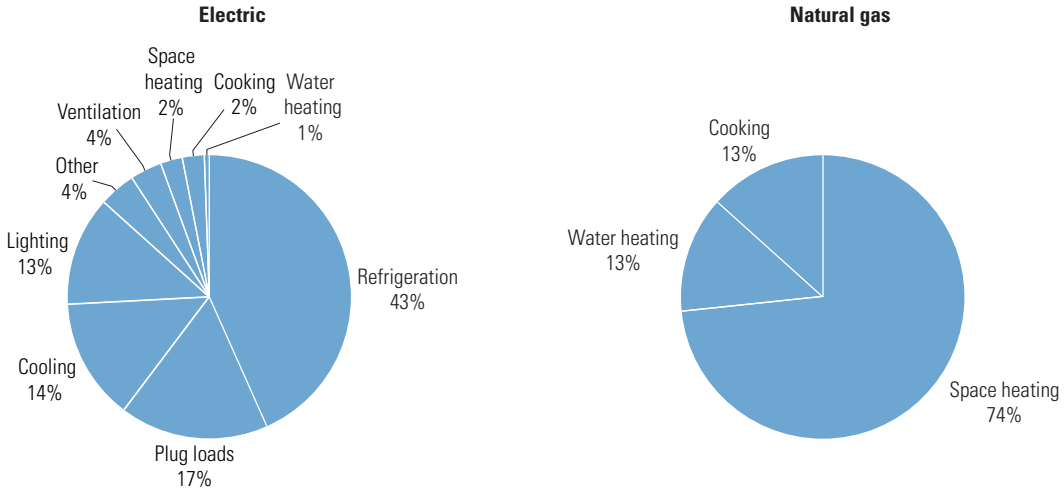
When planning a retrofit strategy, consider a supermarket's largest energy loads. Refrigeration is usually the largest electricity load in a supermarket, and space heating is by far the largest natural gas use (see **Figure 11.1**).

Energy intensity in supermarkets varies widely and is correlated to gross square footage, quantity of refrigeration, and number of workers, although other variables, such as total weekly operating hours and the presence of an on-site kitchen or cooking area, can affect it as well. Energy intensity in supermarkets ranges from less than 136,000 Btu/ft^2 to over 278,000 Btu/ft^2 (**Figure 11.2**, page 4). Given this wide range and skewed distribution, it can be misleading to assess a supermarket facility's performance by looking only at its average energy intensity.

The EPA's national energy-performance rating system is designed to provide a meaningful benchmark for supermarkets. The rating system is accessible online as part of the EPA's free Portfolio Manager tool (www.energystar.gov/benchmark). It evaluates a supermarket's energy intensity, normalizing for weather and operating characteristics. The rating is expressed as a score on a scale of 1 to 100, signifying the percentile of performance. Supermarkets that achieve a rating of 75 or higher are performing in the top quartile and may be eligible to earn

Figure 11.1: Electric and natural gas end-use profile for supermarkets

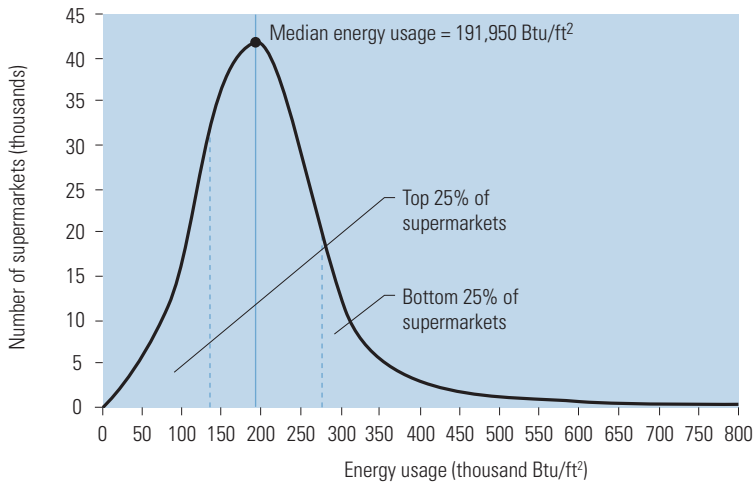
Most of the electricity consumed by supermarkets is used for refrigeration, and space heating typically represents the largest use of natural gas. Each facility's energy profile is different, however, so this chart is not representative of all supermarket buildings. Supermarket electricity use will vary depending on a store's gross square footage and total weekly operating hours, and supermarkets with on-site cooking facilities might see higher levels of gas consumption for cooking.



Courtesy: E SOURCE; from Commercial Building Energy Consumption Survey, 1999 data

Figure 11.2: Distribution of energy intensity in supermarkets

The median supermarket uses approximately 190,000 Btu per square foot (ft^2) from all energy sources. However, many supermarkets are significantly more energy intensive than that.



Courtesy: E SOURCE; from Commercial Building Energy Consumption Survey, 1999 data

the ENERGY STAR label. The rating serves as a standard of comparison against other supermarkets and provides a way to measure progress after upgrades are implemented.

All upgrade projects should begin by establishing a benchmark rating. Ranking stores by their ENERGY STAR performance ratings can help an organization to identify its best- and worst-performing supermarket facilities. Although any supermarket may benefit from retrocommissioning, operational improvements, and retrofits, it is usually most cost-effective to begin upgrade efforts with low-scoring facilities.

For more information, visit ENERGY STAR for Retail at www.energystar.gov/retail; many of the success stories and press releases cover supermarket examples. For a listing of supermarkets that have earned the ENERGY STAR, visit www.energystar.gov/index.cfm?fuseaction=labeled_buildings.showBuildingResults&building_type_id=352&s_code=ALL&profiles=0&also_search_id=NONE.

11.3 Technical Recommendations

Although building systems in supermarkets vary, some common reasons for initiating upgrades of energy-related systems are

- Malfunctions and shortened lifetime of equipment due to improper maintenance and operations, such as excessive cycling of refrigeration compressors due to incorrect refrigerant charge;
- Poor equipment function due to incorrect settings, particularly if settings for refrigerated display cases are altered when the cases are upgraded or moved;
- Changes to interior spaces that have not been accompanied by corresponding changes to heating, cooling, and lighting systems and control regimes;

- Previous attempts to reduce energy use by inappropriate measures, such as covering vents or turning off antisweat heaters in display cases;
- Inadequate ventilation systems, high levels of indoor air contaminants from products or activities (such as cooking), and poor acoustics;
- Multiple rooftop air-conditioning units that are hard to control and maintain properly;
- Refrigerant leaks or phasing out of ozone-depleting refrigerants; and
- Major capital equipment, such as a boiler or a roof, that is nearing the end of its useful life.

Building managers frequently focus on the lowest-cost retrofits with the quickest return on investment, such as lighting. However, substantial energy-saving opportunities for grocery stores are typically available in refrigeration systems. In addition, using the staged approach that is advocated throughout this manual can reveal opportunities for saving on capital costs by "right-sizing" major equipment. After lighting and load-reduction measures (such as refrigeration fixes) have been implemented, it may be possible to specify smaller heating and cooling equipment while maintaining a comfortable ambient temperature.

Many of the following recommendations provide not only energy savings but also maintenance savings. Please note that this should not be considered an exhaustive list of measures appropriate for supermarkets. Supermarket facility directors are encouraged to refer to the full guidelines presented throughout this manual when planning and managing a retrofit program.

Retrocommissioning

Energy savings and other benefits. The biggest savings opportunities uncovered through retrocommissioning of a grocery store typically are in the refrigeration and lighting control systems. As with all commissioning, the amount of savings will depend on the types of problems that are identified and the remedies that are implemented.

Retrocommissioning can produce other benefits. It can reduce equipment downtime and keep maintenance expenditures in check. When problems in lighting and ventilation systems are corrected, retrocommissioning may also create a more pleasing shopping environment. In addition, safety can be verified if the fire-alarm and smoke-detection systems are integrated with other building systems. Problems with low-voltage electrical systems such as lighting, alarm, and building management systems are frequently identified during retrocommissioning.

Best practices. Problems that are simple to fix but costly to ignore are often discovered in a retrocommissioning effort. Supermarkets in particular can reap substantial savings by recalibrating temperature setpoints that may be off by several degrees. Humidity sensors are frequently nonfunctional or inaccurate by several percentage points and may simply need to be cleaned so that air-cooling systems and anticondensate heaters in refrigerated cases are not operating more than necessary. Also, interior lighting controls may not be utilized to best advantage. For example, retrocommissioning may reveal that improperly wired lighting circuits prevent shedding light by zone at store closing and when restocking shelves.

Refrigeration is a major component of food sales, and this equipment should be examined regularly to ensure proper operation. Sometimes retrocommissioning is initiated because problems, such as condensation on refrigerated display case doors, are observed. In that case, commissioning of refrigerated cases can be expanded to encompass the entire building in order to take advantage of the full spectrum of savings opportunities. After a full commissioning, detailed on-site inspection every one to three years to check control settings and the condition

of gaskets, hinges, and motors is usually cost-effective because a few adjustments and minor upgrades can quickly produce significant savings.

Leaks and improper control regimes are typically big opportunities for savings in refrigeration systems. Refrigerant leaks are not just an emissions problem: Incorrect refrigerant levels can compromise efficiency by 5 to 20 percent and raise the risk of early component failure. Although many grocery chains and independent store owners have invested in refrigeration systems equipped with electronic controls, unexpected savings frequently can be found because the controls are not implemented to save energy. When refrigeration systems are installed, controls may be set to operate continuously for worst-case conditions in order to minimize the need for operator attention or to compensate for maintenance-related problems. Portland Energy Conservation Inc. (PECI) in San Diego, California, has found that floating suction pressure control (FSPC) and floating head pressure control (FHPC) strategies can save an annual average of 30,000 to 60,000 kWh from FSPC and 75,000 to 150,000 kWh from FHPC in a typical Southern California grocery store. In cooler climates, even more savings can be achieved through FHPC. Controls to implement FSPC and FHPC may be added as a retrofit and set to adapt automatically to variable conditions.

Internal supermarket operations and maintenance staff may not have sufficient expertise and familiarity with all of the building's systems, and particularly the refrigeration systems, to conduct a commissioning study. Therefore, it is advisable to seek outside experts, who are often able to reveal maintenance and operational problems that are not obvious to customers, sales-floor staff, or custodial crews.

Tune-up opportunities. A number of easy measures can reduce energy use in various areas of a supermarket.

For refrigerated equipment and cold-storage areas:

- Maintain appropriate temperature settings. Energy is wasted if temperature settings in refrigerated systems drift too low. The most commonly used settings for freezers are between –14° Fahrenheit (F) and –8°F. For refrigerators, they are between 35°F and 38°F.
- Clean evaporator coils. The buildup of dirt and ice on evaporator coils slows down the rate of heat transfer and causes the refrigeration system to use more energy to maintain the same temperature.
- Reduce air leakage in refrigerated cases. Replace worn seals and gaskets on refrigerator and freezer doors, install automatic door closers, and use night covers on both vertical and horizontal display cases. Add strip curtains to walk-in doors.

In hot-food preparation areas:

- Minimize preheating energy use by following the manufacturer's recommendations for preheat time and temperature setting. Longer times and higher settings waste energy with no cooking benefit.
- Set cooking schedules to use cooking equipment at full capacity. Fully loaded equipment uses energy most efficiently. Unused and backup equipment can be turned off during low production periods.
- Reduce air leakage in ovens by making sure doors fit tightly and gaskets are in good condition.

In offices and back rooms:

- Make sure HVAC settings in peripheral rooms are at minimum settings during hours of low use.
- Turn off all office equipment and lights during nonbusiness hours. If the computer cannot be turned off, turn off the monitor and the printer.

Training and documentation. The benefits of retrocommissioning can be sustained through proper training of maintenance staff. A retrocommissioning contract should specify that maintenance staff will receive initial training and operating instructions. BetterBricks, an energy-efficiency program operated by the Northwest Energy Efficiency Alliance (NEEA), recommends that grocery store maintenance staff and regular equipment service contractors be present during initial retrocommissioning and any subsequent recommissioning, so that they can receive hands-on instruction in how to maintain proper settings (see sidebar). Operational instructions such as setpoints and schedules should be clearly posted for on-site staff and service contractors. Contracts with equipment service providers can require proficiency in controls management and specify that performance objectives include energy savings in addition to comfort and product safety. Settings on lighting, HVAC, and refrigeration systems should be rechecked every six months, either on-site or remotely through wireless control and monitoring systems. Manuals that document system warranties, instructions for operations, and lists of maintenance requirements should be kept on-site and by the regional manager of facilities.

Training for store managers can cover topics such as equipment warranties and maintenance, operational schedules and setpoints, equipment start-up and shutdown, emergency procedures, and an overview of air-quality and comfort issues. Sales-floor and custodial staff may also benefit from training that includes a discussion of the significance of energy costs and their

CASE STUDY: Lamb's Markets Combines Refrigeration Commissioning with Service Training

Lamb's Markets treats recommissioning of its refrigerated cases as a training opportunity for its regular service contractors. The training is intended to ensure that the savings achieved during recommissioning are retained over the long term. Each store's regular refrigeration service contractor is present during recommissioning and is given the task of taking readings from monitoring equipment and implementing adjustments. This helps to ensure that optimized settings are not changed and controls are not overridden. For example, at Lamb's Palisades Market in Lake Oswego, Oregon, their regular mechanical services contractor spent a day with a BetterBricks refrigeration technical advisor to review and optimize the store's refrigeration systems. (Assistance from BetterBricks, an energy-efficiency program operated by the Northwest Energy Efficiency Alliance, is funded by local energy utilities.) First they reset the holdback valves that determine the lowest allowable refrigerant pressure in the condenser, taking care to maintain system reliability. Next they measured the refrigerant superheat as it exited the evaporator coils and made adjustments to improve the effectiveness of heat transfer in the coil, which reduces compressor run time. After performing those first steps, they were able to raise the suction pressure setpoint on circuits that were operating at lower pressure than necessary. Datalogging before and after the adjustments showed a 9 percent reduction in electric energy use at the main panel. Annual electrical savings in this 27,000-square-foot store exceed $9,000, and the store director reports fewer unanticipated service calls.

relationship to equipment operation, an explanation of lighting schedules, and instructions on covering open refrigerated cases after hours. Such training could be repeated during the year if there were significant staff turnover. Instruction can be provided at meetings, in special training sessions, or in printed manuals and videos of training sessions. The NEEA has created videos specifically to train nontechnical supermarket staff in energy-efficiency procedures.

Integration with facility planning. For supermarket owners with multiple stores, the complete retrocommissioning of selected facilities as well as an assessment of the condition of remaining buildings can be used to develop a multiyear facility management plan. The retrocommissioning efforts could provide a model to follow for planning and prioritizing projects at similar stores while keeping the longer-term impact of those decisions in perspective. A typical facility-condition assessment includes reviewing the age and condition of building components and then estimating their remaining expected lifetime and replacement costs.

Building management systems. Centralized building management systems can help keep supermarket energy systems operating efficiently. Centrally managed chains typically use these systems (also known as energy management systems) in stores larger than 30,000 ft^2 to control refrigeration, space conditioning, and water-heating equipment. By sending data and alarms to a central office, these systems can be used to limit the ability of in-store staff to make changes in settings that would result in inefficient operation.

Lighting

Energy savings. Lighting represents about 13 percent of the electricity consumption in a food sales establishment, not including its impact on cooling loads. Lighting retrofits can save 30 to 50 percent of lighting energy as well as 10 to 20 percent of cooling energy.

Best practices. Competition is pushing stores to create an inviting and exciting shopping experience, which is greatly enhanced by good lighting design. Products need sufficient illumination to attract the attention of shoppers, though care is needed to protect some products from being overheated.

A mixture of light sources inside a grocery store can create an attractive and comfortable environment that accentuates and visually enhances products, thereby driving up sales revenues. A blend of direct and indirect electric lighting can provide soft and uniform illumination. Diffused daylight is particularly attractive lighting for fresh produce and also creates a pleasant background for focused lighting on packaged products. Electric lighting should be coordinated with a daylighting scheme or adjusted in response to it.

The Illuminating Engineering Society of North America (IESNA) sets illumination standards by task. These standards focus on requisite lighting levels; therefore, they do not emphasize daylighting or other energy-saving opportunities. It is also of note that with a good daylighting design, the range of illumination levels can vary more widely than the levels recommended for electric-only scenarios, without negative repercussions.

Daylighting. For many years, grocery stores were designed to let in as little natural light as possible because of concerns that strong glare from sunlight would not only increase the interior cooling load and damage product but also interfere with bar-code scanners. However, properly diffused daylighting has been shown to avoid both of these negative results and offer many benefits. Rather than clear windows and skylights that introduce heat and glare into a supermarket, tints and glazes can be used to diffuse the natural light, creating a pleasant ambience. Combined with appropriate supplemental artificial light, daylighting can provide

optimal illumination and color rendering for product displays. Products and people tend to look better under warm natural light, which has a higher color temperature than the artificial lighting usually used in supermarkets. Grocery store interior designers are changing their attitude about daylighting primarily to improve product appearance and customer experience, so energy savings is a welcome bonus.

Daylight offers two measurable benefits over electric lighting in grocery stores. First, it can save energy by reducing the need for electric lights. Of course, in order to reap those savings, artificial lights must be removed or turned off in response to daylight levels. For example, the supermarket chain Stop & Shop/Giant Food uses energy-efficient T5 fluorescent lighting that dims in response to daylight as one of its energy-saving strategies.

Second, there is some evidence that natural daylight can improve retail sales. A study published in 2003 and sponsored by the California Energy Commission looked at sales in 73 stores belonging to one retailer, 24 of which had a significant amount of daylighting. The study showed that the average effect of daylighting was to increase sales by up to 6 percent. It also found that stores with more hours of useful daylight per year are associated with a greater daylight effect on sales. Researchers concluded that daylighting could boost sales wherever color is among the key selection criteria for products.

Daylighting can be implemented as a retrofit with skylights and light pipes, a relatively low-cost solution that delivers light from roof- or exterior wall–mounted collectors through reflective tubes. Skylight fixtures and light pipes with diffusers can be designed to look like fluorescent fixtures. They can be laid out in a grid, similar to fluorescent lighting, to distribute illumination evenly. Giant Eagle, winner of an ENERGY STAR sustained excellence award, uses skylights for daylighting in its facilities.

Electric lighting. Because electric lights remain on for extended periods of time, substantial savings can be found by making improvements to lighting systems. Many supermarket owners have already upgraded their lighting systems at least once. But auditors continue to find new and overlooked lighting opportunities in supermarkets, even in regions where attention to energy savings has skyrocketed along with energy prices in recent years.

For storewide ambient lighting, efficient linear fluorescent lighting, either T5 lamps or high-performance T8 lamps, can reduce energy consumption by 35 percent or more compared to T12 lighting (as discussed in Chapter 6). In high-bay areas and big-box stores with ceiling heights greater than 15 feet, high-performance T8 and high-output T5 lamps are the most efficient approaches. However, some grocery store owners prefer the look of semispherical metal halide fixtures. In those cases, ceramic metal halide fixtures with electronic ballasts are a good choice. They combine high efficiency with superior color quality.

Supermarkets can also save energy by reducing ambient lighting levels and using spotlighting to attract customers to product displays. Spotlighting can be done with energy-efficient compact fluorescent lights and spot reflectors to direct the light.

For parking and outdoor applications, high-intensity fluorescent (HIF) lighting is often a more efficient choice than high-intensity discharge (HID) lighting. HIF fixtures can provide more even illumination with fewer fixtures than HID lights. To maintain their light output, HIF lamps should be enclosed when used outdoors in cold climates.

Induction lamp technology is a good choice in areas where relamping and maintenance are difficult or hazardous, such as in high-ceiling stores, parking garages, and exterior pedestrian

CASE STUDY: Stater Bros. Retrofits with Light Pipes

Concerned about rolling blackouts caused by California's energy crisis in 2001, Stater Bros. retrofitted six stores with tubular skylights from Solatube to provide backup lighting. Recognizing the energy-saving benefits, the company later installed 164 Solatube light pipes in a new 43,000-square-foot supermarket in Chino Hills, California. During most daylight hours, this free lighting source replaces nearly all of the artificial lighting in the store. Integrated photosensitive controls modulate supplementary artificial lighting in zones throughout the store relative to natural light from the light pipes. This daylighting system is estimated to cut the store's lighting energy costs in half.

lighting. These products typically have long lifetimes (up to 100,000 hours, compared to 24,000 hours for HID lights), which means infrequent relamping. Moreover, they offer good lumen maintenance, compact construction, and vibration resistance. Induction lamps can start at temperatures as low as –40°F with no delay and operate at those temperatures without significant loss of lumens.

Light-emitting diodes (LEDs) are a good light source for several supermarket applications. In addition to the common exit-sign retrofit, LEDs are also an efficient alternative to neon lighting for grocery department signs.

LEDs additionally offer some advantages over fluorescent lamps for refrigerated-display-case lighting. The most important feature is that they perform very well in cold temperatures, unlike fluorescent lamps, for which light output drops appreciably with temperature. LEDs are directional in nature, allowing light to be directed just where it is needed inside the case. Also, with fluorescent lighting most of the waste heat is dissipated inside the case, whereas the heat sink for an LED can be moved outside the case entirely, resulting in reduced refrigeration energy needs. In addition, a study conducted by the Lighting Research Center at the Rensselaer Polytechnic Institute found that customers perceived LED illumination in freezers to be "brighter, more even, more appealing, and more comfortable" than fluorescent lighting, even when the LEDs operated at a lower average light level than the fluorescent bulbs. Wal-Mart has announced plans to use LED lighting in the refrigerated display cases of 500 stores. The LEDs will be integrated with occupancy sensors and will automatically dim when no customers are nearby.

A good option for accent lighting of perishable goods is remote-source lighting, in which a single high-efficiency light source feeds multiple remotely placed fixtures via fiber-optic cables. The systems can be costly, but the ability to keep infrared radiation away from produce while still illuminating the goods in an efficient, attractive manner is a big plus.

Controls. Occupancy sensors save energy but also help to reduce maintenance costs by lengthening the relamping interval. In storage rooms, break rooms, offices, and restrooms, ceiling-mounted ultrasonic occupancy sensors can be used to detect occupants, even around partitions and corners. Food Lion installed occupancy sensors in break rooms and storage rooms as one of its first energy-saving measures (see sidebar, page 11). For areas that use daylighting, automatic dimming controls can be used to ensure that minimum light levels are met while saving energy. A photocell control can instruct outdoor lighting to turn on and off based on light levels, or an astronomical clock can be used like a timer and set to adjust automatically to daylight saving time.

CASE STUDY: Food Lion's Major Lighting Overhaul

Since 2000, through lighting, refrigeration, and HVAC retrofits and companywide energy management efforts, Food Lion has reduced its energy use by 27 percent. This total savings is equivalent to eliminating energy use entirely at 457 of its 1,200 stores. Lighting is a big part of this grocery chain's energy-saving efforts. Food Lion completed a major lighting overhaul in 2003, swapping T-12 with T-8 fixtures and lamps across the chain. Energy efficiency was just one goal of the relamping effort. The new lighting systems also improve the quality of light, work environment, and safety, according to a regional maintenance manager at the company. They have also helped the company achieve ENERGY STAR status for over 700 stores. As the chain progresses toward its goal of earning the ENERGY STAR for every store, lighting upgrades will include T-5 and LED systems.

Load Reductions

Energy savings. Load reduction measures that reduce the operational time or intensity of HVAC equipment while still maintaining a comfortable shopping and work environment can offer substantial savings. Refrigeration is by far the largest load in a grocery store, representing an average of 43 percent of supermarket electricity usage. Significant energy savings can be gained not only from regular refrigeration tune-ups and maintenance but also through retrofits and cost-effective replacements of older refrigeration equipment.

In addition to refrigeration, load-reduction strategies should include cooking equipment, which represents 13 percent of natural gas purchased by grocery stores. Many store owners have added or are expanding food service, either under their own brand or through partnerships with in-store tenants. For these establishments, consider purchasing ENERGY STAR qualified cooking equipment, which uses 10 to 50 percent less energy than conventional models. Often this equipment not only offers significant return on investment because of these savings but also features longer operating lifetimes and lower maintenance requirements, with no negative impact on cooking performance.

Best practices. The quickest and easiest way to implement load reductions is to ensure that equipment is turned off when it is not needed. Sales, custodial, or other staff can be recruited to accomplish this effort. For example, lights can be turned on by zone as needed in the morning, beginning with the bakery and meat departments. Staff should be informed of the automated schedules for lighting and other systems so that they understand the purpose of those schedules and do not override them unless necessary. Food Lion has cut utility costs per store by over 5 percent through such operational measures, motivating maintenance staff to save energy with quarterly bonuses.

For stores with food service, simply reducing the operating time of kitchen appliances when they are not needed can cut cooking-related energy consumption by up to 60 percent. If turning equipment on and off during store hours is inconvenient, choose equipment that uses less energy when idle. For example, rapid-cook ovens (which combine microwave with other heating technologies) have a very low power draw when idle.

Some maintenance procedures are widely known but are not regularly followed. Cleaning frost off refrigeration evaporator coils should be a top priority in every store's maintenance routine. The regular maintenance schedule should also include cleaning HVAC condenser coils and replacing filters. It is very important to keep rotisserie ovens clean because poor maintenance can dramatically interfere with cooking speed as well as their appearance to customers.

Equipment placement is also important. Do not install air-cooled refrigeration equipment in areas with poor air movement, such as a tight corner. Ice-making and refrigerated vending machines require good air circulation; poor air circulation reduces their operating efficiency.

The way goods are placed in refrigerated display cases can also affect display-case loads. Avoid overloading shelves and blocking air flows. Tests have shown that the common nonuniform loading arrangements used in supermarkets, including some overfilled shelves, gaps in other shelves, and partial blockage of return air, have a big effect on the cooling effectiveness of cases. Also, for cases that use air curtains, products should be placed so that they do not interfere with the curtain operation.

Efficient-equipment procurement. Manufacturers of refrigeration and cooking equipment are increasingly aware of their customers' concern regarding lifetime operational costs, including those for energy and maintenance. They are responding to customer demand by producing much-higher-efficiency equipment than was standard just a few years ago. For example, the latest medium-temperature cases feature higher evaporator temperatures, more-efficient compressors, better fan motors, less-frequent defrost cycles, and more-efficient lighting. Many grocery chains are opting for medium-temperature cases with doors, ignoring outdated assumptions about customer preferences and recognizing that customers regularly use such cases in convenience stores. In fact, the owner of Vic's Market in Sacramento, California, has found that customers tend to linger in freezer aisles longer since he installed closed refrigeration cases, which keep the aisles more comfortable for shoppers. By maintaining detailed cost records of existing equipment, managers may find that frequent repairs to a display case, ice maker, or food warmer cost more than replacement with a more efficient model.

Supermarket owners are also assessing the cost of retrofits compared with equipment replacement in light of the Clean Air Act's upcoming ban on the production and import of the popular refrigerant HCFC-22 for newly manufactured equipment. The ban will take effect January 1, 2010. Now may be an opportune time to purchase more-efficient equipment while proactively complying with Clean Air Act regulations. Some supermarkets are shifting from central-rack refrigeration systems to distributed systems with multiple smaller compressors located near the displays. Distributed systems require less refrigerant, piping, and energy to pump coolant throughout the store. Not only do they operate more efficiently at lower condensing temperatures, but this switch also offers product-display flexibility and better use of floorspace.

A simple way to ensure that purchased equipment is energy efficient is to request that procurement staff specify ENERGY STAR qualified products in their contracts or purchase orders (www.energystar.gov/purchasing). Some ENERGY STAR qualified products that are relevant for grocery stores include

- Commercial solid-door, reach-in refrigerators and freezers
- Commercial fryers, steam cookers, and hot-food holding cabinets
- Commercial dishwashers
- Commercial ice makers
- Computers and monitors
- Vending machines
- Roof products

For example, replacing three conventional refrigerated-beverage vending machines with ENERGY STAR qualified models would mean annual operational savings of $390 because they are 40 percent more energy efficient. (Savings will vary depending on electricity rate.) Purchasing an ENERGY STAR qualified commercial ice machine can save about 1160 kWh annually, or an average of $100 per year on utility bills compared with conventional models. Each individual ENERGY STAR qualified commercial refrigerator can save $140 per year and reach simple payback in just 1.3 years. Companies such as Albertsons and Winn-Dixie are specifying energy-efficient coolers and freezers for their stores, including models with no-heat anticondensation glass doors and high-vacuum cases that can operate at a higher temperature, reducing defrost time.

Product recommendations from the U.S. Department of Energy's Federal Energy Management Program may be appropriate for items not covered under the ENERGY STAR program. In addition, useful data on food preparation equipment performance are available from test laboratories such as the Food Service Technology Center (see sidebar, page 14).

Retrofits. Many retrofit options for refrigeration systems promise significant savings and quick payback and are relatively simple to install. For example, the latest antisweat heater controls sense humidity in the store's ambient air and reduce operation of antisweat heaters in low-humidity conditions. Electronically commutated motors use about one-third the energy of the typical evaporator-fan motors in walk-in coolers. This upgrade can pay off within one year, depending on electricity rates.

CASE STUDY: EnergySmart Grocer Program Helps Grocery Chain Cut Refrigeration Loads

The EnergySmart Grocer Program managed by Portland Energy Conservation Inc. (PECI) provides grocers with energy audits and information about efficient technology, operations, and management options that help to identify energy-saving opportunities and the financial benefits of increasing efficiency in their stores. For example, the program has helped a regional grocery chain in the San Francisco Bay area save over 350,000 kilowatt-hours (kWh) and $53,000 per year by installing energy-saving measures in three of its stores. In one 25,000-square-foot (ft^2) store, a PECI EnergySmart Grocer field energy analyst inspected the facility and recommended two phases of retrofits, beginning with simple measures for immediate results followed by retrofits for longer-term savings. The first phase involved adding 196 linear feet of night covers to open display cases to reduce the cooling load during off hours, cutting annual electricity use by 2,000 kWh. Strip curtains installed in walk-in freezers produced more-significant savings, reducing energy use by over 30,000 kWh for a 91-ft^2 doorway. Also as part of the first phase of retrofits, installation of antisweat heater controls is saving another 30,000 kWh per year for 120 linear feet of refrigerated-display-case doors.

The second phase of retrofits involved replacing low-temperature open refrigerated cases with new high-efficiency reach-in units that feature electronically commutated motor (ECM) fans and T8 lamps with electronic ballasts, saving 60,000 kWh per year with 62.5 linear feet of replacement cases. The store also installed 36 ECMs in place of existing shaded-pole evaporator-fan motors, providing approximately 20,000 kWh of annual savings. Another 234 feet of night covers were added for additional savings of nearly 2,400 kWh per year.

Another retrofit option is a "smart" defrost controller kit that monitors several variables and optimizes the number of daily defrost cycles for walk-in freezers. Smart defrost controllers can save hundreds of dollars each year, depending on the size of the freezer. Working with a store's regular refrigeration service contractor when installing such a system will help discourage technicians from disabling the controllers to avoid possible service calls.

For stores that serve prepared food, prerinse spray valves, which remove food waste from dishes prior to cleaning in a dishwasher, are easy to install and reduce water consumption, water heating energy, and sewer charges. Look for models with a flow rate of 1.6 gallons per minute or less. In hot-food preparation areas, intelligent variable-speed hood controller systems can also significantly reduce energy costs. A photoelectric smoke or heat detector determines when and how much ventilation is needed and activates the exhaust fan at the proper speed. This

RESOURCES: Load Reductions

The following organizations offer resources that help owners and operators of supermarkets to assess how effectively they currently use energy and to investigate efficient alternatives.

Food Marketing Institute
www.fmi.org/sustainability/

The Food Marketing Institute is a nonprofit association that conducts programs in research, education, industry relations, and public affairs on behalf of its members and their subsidiaries, which include food retailers and wholesalers and their customers in the United States and around the world.

Food Service Technology Center
www.fishnick.com

The Food Service Technology Center is a fuel-neutral scientific testing facility for benchmarking the energy performance of equipment used in commercial kitchens.

Northwest Energy Efficiency Alliance, Grocery Market Program
www.betterbricks.com/subHomePage.aspx?ID=2

This program focuses on the efficient design and construction of new stores and improving energy use in existing stores. Information, tools, and training and support are provided with the aim of changing business practices related to energy management.

Portland Energy Conservation Inc.
www.peci.org/overview_cxtech.html

This organization provides assistance to governmental agencies and energy providers in implementation of energy-savings initiatives. It also hosts the annual National Conference on Building Commissioning and maintains free online reference material on commissioning.

U.S. Department of Energy, Federal Energy Management Program
www1.eere.energy.gov/femp/procurement

The Federal Energy Management Program maintains a database of energy-efficient products that is complementary to ENERGY STAR's list of qualified products, plus guidelines for equipment procurement.

technology can yield a one- to two-year simple payback. However, makeup air to the cooking area may need to be adjusted to compensate for variable operation of the vent hoods.

Most supermarkets are single-story buildings with large footprints, which means they have a high ratio of roof area to total facility square footage. This makes them good candidates for cool-roof solutions. If a supermarket building's roof needs recoating or painting, white or some other highly reflective color can minimize the amount of heat that the building absorbs. This change can reduce peak cooling demand and cooling energy use by 15 to 20 percent, depending on the climate zone in which the store is located.

Air Distribution Systems

Energy savings. Although ventilation systems consume only about 4 percent of the electricity used in grocery stores, there are opportunities for cost-effective efficiency measures. Savings can be found by installing efficient fan motors and sizing the system to match the load (which may now be lower due to measures adopted in earlier stages). Even more savings are possible by using variable-speed drives.

Best practices. A ventilation system must be designed, operated, and maintained to provide adequate fresh-air intake and prevent mold growth from unwanted moisture accumulation. ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) Standard 62.1, "Ventilation for Acceptable Indoor Air Quality," establishes minimum ventilation levels for several types of retail spaces.

Insufficient ventilation air is often due simply to clogged intake screens that are difficult to access for inspection and cleaning. To prevent this problem, ensure that all HVAC system air-supply diffusers, return registers, and outside-air intakes are clean and unobstructed. Replace filters regularly. These measures to improve ventilation rates should not raise energy consumption.

Insufficient ventilation air may also occur with scheduled ventilation and variable-air-volume systems or may be caused by wind, stack effects, or unbalanced supply and return fans. Installing an outdoor-air-measuring station that modulates the outdoor-air damper and return damper is relatively simple and ensures a sufficient fresh-air supply. Increasing ventilation to safe and comfortable levels will likely increase energy consumption and so should be combined with other energy-saving measures.

It is also possible to bring in too much outside air, which many facilities do during warm and humid periods. In warm months, it can be effective to reduce outside-air intake, especially when humidity is high. If a facility is overventilating, then decreasing ventilation levels can produce energy savings in both the distribution system and the cooling and heating system.

Retrofits. For humid climates and high-occupancy buildings, dedicated outdoor air systems (DOASs) improve humidity control and can produce energy savings. In retrofit applications, the DOAS airstream can be brought into the building's ductwork through a mixing box or through the existing HVAC system. Either way, desiccant systems used as part of the DOAS can relieve mechanical air-conditioning systems of the duty of dehumidifying outdoor air.

Heat-recovery ventilators and energy-recovery ventilators have balanced exhaust and supply fans that meet all ventilation needs without creating drafts and air-pressure imbalances. Heat-recovery ventilators can feature efficiencies as high as 85 to 95 percent, with payback in roughly three and a half years. Consider these units wherever air is continuously exhausted and makeup or ventilation air is required, as in a food preparation area.

Outside-air intake can be reduced during known low-occupancy periods, such as late-night restocking or as determined automatically by carbon dioxide sensors. Declining costs for implementing demand-controlled ventilation (DCV) have made it attractive for use in supermarkets, which typically have high-variable occupancy. DCV provides the greatest savings if a store's occupancy is highly variable, it is open for long hours, it is located in a moderate to extreme heating or cooling climate, and its existing HVAC system does not use 100 percent outdoor air. Annual energy savings can amount to as much as $1 per square foot. Since DCV reduces the amount of outdoor air brought in, groceries with food service should take care to provide enough ventilation to remove any related fumes.

Heating and Cooling Systems

Energy savings. Cooling systems consume approximately 14 percent of the electricity used by grocery stores in the U.S., and space heating represents nearly 75 percent of natural gas used by the food-sales sector. High-efficiency rooftop units can save a significant amount of energy, particularly for cooling, and can reach payback within two years, depending on cooling loads and electricity prices.

Best practices. Heating, cooling, and refrigeration systems often compete with each other in grocery stores. If infiltration of cold air from freezer aisles is controlled (such as with doors, night covers, and air curtains in display cases), less space heating is required throughout the store.

Humidity control is particularly important in grocery stores because humidity can cause refrigeration systems to develop frost buildup and condensation on display-case doors. Desiccant dehumidification and/or energy recovery systems can be efficient and effective strategies for handling large humidity loads.

Retrofits. Commercial packaged rooftop units are the most common cooling system used in food-sales facilities, followed by residential-type central air conditioners. If packaged equipment is in need of replacement, using high-efficiency instead of standard-efficiency units can provide attractive savings. This is also an excellent opportunity to capitalize on the myriad other measures taken to reduce loads and losses throughout the facility. Take advantage of savings from all other building improvements by right-sizing heating and cooling equipment to meet actual needs rather than relying on rule-of-thumb sizing estimates. Too often this equipment is oversized, which means the systems rarely operate at peak efficiency. Right-sizing offers first-cost savings as well.

Economizers can be added to many systems to provide free cooling during spring and fall or on cool summer nights when the humidity level is not too high. In humid areas, they should be used with differential enthalpy controllers. Economizers must be checked regularly to ensure that their dampers are functioning properly. Dampers that are stuck open could be letting in too much outside air, and ones that are stuck closed will not provide the benefit of free cooling.

Central energy management systems can generate savings by effectively and automatically controlling multiple rooftop units to establish appropriate temperature setpoints, turning off equipment at night, and tracking energy use. Multisystem building management systems are available to monitor and control not only HVAC but also refrigeration and lighting, all from a remote location. In a two-year period, Wild Oats cut energy usage by 4.4 million kWh of electricity, which translated into an annual cost savings of $512,369, mainly due to reprogramming of settings and controls via building management systems.

Heat recovery systems can be added to refrigeration equipment to capture heat in the form of hot water. A 7.5-horsepower compressor can provide nearly 100 percent of the hot water

needed in a medium-sized grocery store. The hot water can be used for kitchen cleanup areas or bathroom sinks, or it can be run through a heat exchanger for space heating in cold weather. Hannaford Bros. Co. stores in the Northeast and PCC Natural Markets in the Northwest both use heat reclamation to displace fossil fuels for space and water heating.

11.4 Financial and Implementation Issues

Recognizing the challenges and opportunities of saving energy in grocery stores, many energy utilities and governmental programs target this sector with rebates, financing, and informational assistance to promote energy-saving retrofits and operational fixes. By taking advantage of subsidies from its energy provider and considering other indirect benefits such as reduced losses of perishable goods, Albertsons has significantly improved its estimated rate of return on energy-efficiency projects.

Conducting upgrades in supermarkets located in multiuse buildings and leased space likely will need special consideration. The ability to upgrade some or all of the building systems in a particular space will depend on lease agreements, whether spaces are served by their own HVAC or other equipment, whether spaces are submetered, and the building owner's willingness to participate in the process. One way to enable a retrocommissioning or equipment upgrade is to share costs and savings between the building owner and tenants. Hines, one of the largest real estate organizations in the world, uses this model to implement building upgrades so that affected tenants do not pay extra during the payback period and after that reap pure savings.

The ENERGY STAR Cash Flow Opportunity Calculator (www.energystar.gov/index.cfm?c=tools_resources.bus_energy_management_tools_resources) can help grocery store owners calculate how much they can afford to invest in retrofits from the anticipated savings and whether it would make sense to borrow funds to finance building upgrades.

Supermarket owners can also consider third-party performance or shared-savings contracting, which provides a mechanism to fund energy-saving retrofits and to cover deferred maintenance and capital renewal projects at the same time. The combination of refrigeration and lighting retrofits with the addition of an advanced building management system can be an excellent retrofit bundle for a performance contract, partly because continuous performance monitoring can be built in. In addition, including ongoing maintenance in a performance contract can help to keep operating and maintenance costs under control and predictable. This is particularly relevant for grocery store owners that would normally outsource system maintenance, because performance objectives would be built into the contract. Having a long-term contract in place should also provide an impetus for long-term strategic planning of equipment upkeep and replacement.

Bibliography

BetterBricks, "PCC Natural Markets," www.betterbricks.com/DetailPage.aspx?ID=270 (accessed December 2007).

Cofer, Steve (August 2007), Program Manager, Portland Energy Conservation Inc., 503-595-4472, scofer@peci.org.

Coia, Anthony, "Energy Smart," *Supermarket News* (June 30, 2003).

Criscione, Peter, and Ira Krepchin, "Long Live Electrodeless Lamps," *E Source Report, ER-02-6* (May 2002).

"Desiccant Dehumidification," U.S. Department of Energy, www.eere.energy.gov/buildings/info/components/hvac/cooling/desiccant.html (accessed July 2007).

Ellis, George, "Let the Sun Shine In," *Supermarket News* (June 25, 2007).

EnergyIdeas Clearinghouse, "Grocery Store Energy Conservation," www.energyideas.org/default.cfm?o=h,g,ds&c=z,z,4447 (accessed November 2007).

Fedrizzi, Rick, and Jim Rogers, "Energy Efficiency Opportunities: Big Box Retail and Supermarkets," report prepared for The Center for Energy and Climate Solutions (May 2002), http://files.harc.edu/Sites/GulfCoastCHP/MarketAssessments/EnergyEfficiencyOpportunitiesBigBox.pdf.

Food Marketing Institute, "Supermarket Facts, Industry Overview 2006," www.fmi.org/facts_figs/superfact.htm (accessed August 2007).

Heschong Mahone Group, "Daylight and Retail Sales" (October 2003), report prepared for the California Energy Commission, www.h-m-g.com/projects/daylighting/projects-PIER.htm.

Innovest Strategic Value Advisors, "Energy Management and Investor Returns: The Retail Merchandising Sector" (February 2003), www.energystar.gov/ia/business/guidelines/assess_value/merch.pdf.

Krepchin, Ira, and Stan Walerczyk, "New Capabilities for High-Bay Metal Halide Technology," *E Source Technology Assessment Service, ER-05-3* (January 2005).

Levin, Diane, and Lawrence Paulsen, "Supermarket Controls and Commissioning: Uncovering Hidden Opportunities," 2006 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Buildings.

Litwak, David, "Bringing It All Together: Manufacturers Are Tying in Many Small Improvements to Generate Greater Energy Efficiency in Their Medium-Temperature Cases," *Grocery Headquarters*, vol. 72, no. 2 (February 1, 2006), pp. 101–104.

Litwak, David, "Power Stretch: Reducing Stores' Energy Consumption Has Become a Top Priority for Virtually Every Supermarket Operator," *Grocery Headquarters*, vol. 72, no. 9 (September 1, 2006), pp. 109–112.

Pacific Power, "Albertsons," Energy FinAnswer Case Study (February 2007), from www.pacificpower.net/File/File72005.pdf (accessed December 2007).

Romico, Michael, "Cool Running," *Foodservice Equipment Reports*, vol. 11, no. 7 (July 2007), p. 53.

Sherer, Mike, "Figuring the Value of Equipment," *Foodservice Equipment Reports*, vol. 11, no. 7 (July 2007), pp. 31–32.

Southern California Edison, "Supermarket Display Case Shields," www.sce.com/RebatesandSavings/LargeBusiness/Commercial/SupermarketDisplayCaseSheilds (accessed November 2007).

Southern California Edison, "Testing Evaluates the Performance of a Refrigerated Display Case," www.sce.com/RebatesandSavings/LargeBusiness/Commercial/RefrigeratedDisplayCase (accessed November 2007).

Squazzo, Jessica, "Saving Energy, Cutting Costs," *Grocery Headquarters* (August 2004).

U.S. Department of Energy (DOE), Energy Information Administration (EIA), Commercial Building Energy Consumption Survey (CBECS), "End-Use Consumption by Principal Building Activity" (1999 data; published 2003), www.eia.doe.gov/emeu/cbecs/enduse_consumption/pba.html.

U.S. DOE, EIA, "2003 Commercial Building Energy Consumption Survey (CBECS), Public Use Microdata Files" (published 2006).

U.S. Environmental Protection Agency, ENERGY STAR, "Food Lion, LLC, Partners in Practice," case study, www.energystar.gov (accessed August 2007).

Warila, Paul (August 2007), Project Manager, Northwest Energy Efficiency Alliance, 503-827-8416, pwarila@nwalliance.org.

Zimmerman, Kim Ann, "Putting a Chill on the Energy Bill," *Grocery Headquarters* (August 2007).