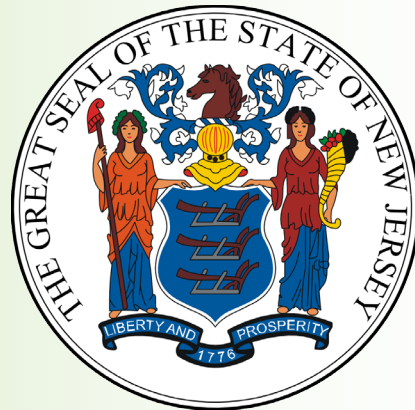


Supermarkets: Best Practices

New Jersey Board of Public Utilities



RUTGERS

CAES 

The CAES logo consists of a black oval containing three red, overlapping, wavy lines that resemble a stylized signal or waveform.

Produced For:

New Jersey Board of Public Utilities

Office of the Business Energy Ombudsperson

Two Gateway Center

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1 Introduction

New Jersey's food system ensures access to food by the state's residents and facilitates the production and distribution of food products across the U.S. and world. The food system generated sales in excess of \$82 billion in 2002 and directly contributed \$19 billion to gross state product (GSP). When the economic linkages to supporting industries and induced consumer spending are considered, the state's food system accounted for 8.5 percent of New Jersey's 2002 private sector GSP. The food system is also a large employer, providing jobs for about 400,000 workers (as of March 12, 2002). These employment contributions swell considerably when linkages to other industries are measured, such that 15.2 percent of all private sector jobs in the state support – either directly or indirectly – businesses engaged in the production, processing, or distribution of food.*

According to the New Jersey Food Council, the typical supermarket is 65 – 70,000 square feet in size. Their members feed nine million people each day.

This guide was developed to help supermarkets save energy, reduce waste, and become the environmental leaders in their field. Facilities that take the early initiative on ever-growing environmental concerns will be poised to lead New Jersey to a cleaner, brighter future. This manual outlines all the practices that can help save your facility money without spending a penny, in addition to presenting guidelines for investing money wisely into energy efficiency and green energy.

The manual was produced by the Center for Advanced Energy Systems (CAES) at Rutgers, The State University of New Jersey. CAES is a multi-disciplined, full-service energy center including thrusts in research, teaching, and outreach.



Supermarket Energy Use

According to discussions with supermarket managers in New Jersey, supermarkets typically have an average annual energy cost of more than \$10 per square foot.

Other Resources for Supermarkets:

Food Marketing Institute, Energy & Technical Services Conference www.fmi.org/events

Edison Electric Institute, National Accounts Workshops www.eei.org/meetings/

Northwest Energy Efficiency Alliance, Grocery Market Program
www.nwalliance.org/ourwork/projectsummary.aspx?ID=91

*The Food Policy Institute at Rutgers University

(Data received from 2003 CBECS from the Energy Information Administration)

2 Energy Management & Procurement

Sustainability in Business

Sustainability is a word that's thrown around the business world a lot lately... and with good reason. Sustainability is defined as "a process or state that can be maintained at a certain level indefinitely". While a 100% sustainable business is very difficult to obtain, a business that works towards sustainability gains a positive image while hedging long-term fiscal risks.

Working towards long-term goals is what sustainability is all about. Uncertainty and volatility in energy markets keeps energy-dependent businesses at the whim of oil prices. Energy efficient equipment and conservation practices don't only benefit the environment, but also buffer businesses to energy price spikes.

Life Cycle Costing

Life cycle costing is a method for evaluating project viability that breaks the mold of traditional return on investment. In life cycle costs, one analyzes not only the initial costs, but also the costs over the life of a project. By taking a long-term perspective, one can justify projects and equipment purchases that don't have an attractive, short return on investment. Oftentimes the cost of operations and maintenance of equipment far outweighs the initial costs. In such cases, LCC shows that it is prudent to purchase a high-efficiency, low maintenance piece of equipment at a higher initial cost.

LCC can also be applied to renewable energy systems. A photovoltaic system is currently almost impossible to justify by traditional costing methods. If using LCC, however, the long-term return on electricity produced can justify such a project. Since photovoltaics are solid-state devices, maintenance is low and long-term viability is high.

For more information on life cycle costing, please visit the following web links:

- Whole Building Design Guide
(<http://www.wbdg.org/resources/lcca.php>)
- NIST Life-Cycle Costing Manual
(fire.nist.gov/bfrlpubs/build96/PDF/b96121.pdf)

N.J. Rebates & Incentives

Courtesy: New Jersey Board of Public Utilities Clean Energy Program, <http://www.njcleanenergy.com> ; DSIREUSA.org, <http://www.njheps.org>, <http://www.aceee.org>, <http://www.epa.gov>

IMPORTANT: All specific rebate information provided in this manual is accurate and up to date as of June 2009 and is subject to change. Please visit the New Jersey Clean Energy Program website for the most up to date and accurate information.

NJ SmartStart Buildings

<http://njcleanenergy.com/commercial-industrial/programs/nj-smartstart-buildings/nj-smartstart-buildings>

Whether you're starting a commercial or industrial project from the ground up, renovating existing space, or upgrading equipment, you have unique opportunities



to upgrade the quality of the project. New Jersey SmartStart Buildings can provide a range of support — at no cost to you — to yield substantial savings, both now and for the future.

Incentives for new construction are available only for projects in areas designated for growth in the NJ State Development and Redevelopment Plan. Public school (K-12) new construction projects are exempted from this restriction and are eligible for Program incentives throughout the State.

NJ SmartStart Buildings Services include:

- * Design Support for Larger Projects
- * Technical Assistance for Smaller Projects
- * Custom Measures Rebates
- * Incentives for Qualifying Equipment and Projects (See next page)

When planning to construct a new supermarket, one should certainly consult the SmartStart Buildings program to receive financial and technical assistance.

Pay for Performance

Pay for Performance is directed at large existing facilities in a manner that directly links incentives to energy savings in a whole-building approach. Pay for Performance will rely on a network of Program Partners who provide technical services under direct contract to building owners. These Partners will develop an Energy Reduction Plan for each project that includes technical components typically found in a traditional energy audit, a financial

NJ SmartStart Program**Electric Chillers**

Water-cooled chillers	\$12-\$170 per ton
Air-cooled chillers	\$8-\$52 per ton

Gas Cooling

Gas absorption chillers	\$185-\$450 per ton
Gas Engine-Driven chillers	Calculated through Custom Measure Path
Desiccant Systems	\$1 per cfm - gas or electric

Electric Unitary HVAC

Unitary AC and split systems	\$73-\$92 per ton
Air-to-air heat pumps	\$73-\$92 per ton
Water-source heat pumps	\$81 per ton
Packaged terminal AC & HP	\$65 per ton
Central DX AC Systems	\$40-\$72 per ton
Dual Enthalpy Economizer Controls	\$250

Ground Source Heat Pumps

Closed Loop & Open Loop	\$370 per ton
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Gas Heating

Gas-fired boilers < 300 MBH	\$300 per unit
Gas-fired boilers ≥ 300 MBH - 1500 MBH	\$1.75 per MBH
Gas-fired boilers ≥ 1500 MBH - ≤ 4000 MBH	\$1 per MBH
Gas-fired boilers > 4000 MBH	Calculated through Custom Measure Path
Gas furnaces	\$300-\$400 per unit

Variable Frequency Drives

Variable air volume	\$65-\$155 per hp
Chilled-water pumps	\$60 per hp
Compressors	\$5250 to \$12500 per drive

Natural Gas Water Heating

Gas water heaters ≤ 50 gallons	\$50 per unit
Gas-fired water heaters > 50 gallons	\$1-\$2 per MBH
Gas-fired booster water heaters	\$17-\$35 per MBH

Premium Motors

Three-phase motors	\$45-\$700 per motor
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Prescriptive Lighting

T-5 and T-8 lamps with electronic ballast in existing facilities	\$10-\$30 per fixture, depending on quantity of lamps
Hard-wired compact fluorescent	\$25-\$30 per fixture
Metal halide w/pulse start	\$25 per fixture
LED Exit signs	\$10/\$20 per fixture
T-5 and T-8 High Bay Fixtures	\$16-\$284 per fixture

Lighting Controls**Occupancy Sensors:**

Wall mounted	\$20 per control
Remote mounted	\$35 per control
Daylight dimmers	\$25 per fixture controlled
Occupancy controlled hi-low fluorescent controls	\$25 per fixture controlled

HID or Fluorescent Hi-Bay Controls:

Occupancy hi-low	\$75 per fixture controlled
Daylight dimming	\$75 per fixture controlled

Other Equipment Incentives*

Performance Lighting	\$1 per watt per sq ft below program incentive threshold**
Custom electric and gas equipment incentives	not prescriptive

* Equipment incentives are calculated based on type, efficiency, size, and application and are evaluated on a case-by-case basis

**currently 5% more energy efficient than ASHRAE 90.1-2004 for New Construction and Complete Renovation

plan for funding the energy efficient measures and a construction schedule for installation. Incentives will be awarded as program milestones are completed with the final incentive paid following a comprehensive measurement and verification report that proves the savings targets have been met or exceeded. In addition, Pay for Performance projects that incorporate Combined Heat & Power (CHP) will be eligible for additional incentives.

Incentive levels break down as follows:

- Incentive #1 - Submittal of complete Energy Reduction Plan prepared by an approved Program Partner - Contingent on moving forward, incentives will be between \$5,000 and \$50,000 based on approximately \$.10 per square foot, not to exceed 50% of the facility's annual energy expense.
- Incentive #2 - Installation of all recommended measures - Incentives are based on the projected level of electricity and gas savings, which will be "trued-up" after one year based on actual savings.
- Incentive #3 - Completion of Measurement and Verification Report - A completed report verifying energy reductions based on one year of post-implementation results is required. Incentives for electricity savings and natural gas savings will be paid based on actual savings, provided that the minimum performance threshold of 15% savings has been achieved.

It is also important to note that Combined Heat & Power (CHP) projects are eligible for incentives up to \$1,000,000 as part of Pay for Performance.

Existing commercial, industrial and institutional buildings with an average annual peak demand over 200 kW are eligible to participate including hospitals, hotels and casinos, large office buildings, multi-family buildings, supermarkets, manufacturing facilities, schools, shopping malls and restaurants. Your Energy Reduction Plan must define a comprehensive package of measures capable of reducing the existing energy consumption of your building by 15% or more.

Pay for Performance takes advantage of the ENERGY STAR Program with Portfolio Manager, EPA's interactive tool that allows facility managers to track and evaluate energy and water consumption across all of their buildings. The tool provides the opportunity to load in the characteristics and energy usage of your buildings and determine an energy performance benchmark score. You can then assess energy management goals over time, identify strategic opportunities for savings, and receive EPA recognition for superior energy performance.



Direct Install

The Direct Install Program will address small commercial and industrial facilities with peak demand of less than 200 kW. This turnkey program is aimed at providing owners a seamless, comprehensive process for analysis, equipment replacement and financial incentives to reduce consumption, lower utility costs and improve profitability.

The Direct Install Program is designed to identify cost-effective energy efficiency retrofit opportunities and provide direct installation and financial incentives for up to 80% of installed cost to encourage the early replacement of existing equipment with high efficiency alternatives. Systems and equipment eligible for incentives include lighting, controls, refrigeration, HVAC, motors, variable speed drives, natural gas and food service. The program will strive to result in the installation of a comprehensive package of cost-effective energy efficiency improvements for each project. Direct install will be a turnkey program utilizing selected, participating contractors. Energy assessments will be conducted as part of the Direct Install Program to identify energy efficiency improvement opportunities at the owner's facility.

Solar Renewable Energy Credit (SREC) Program

Solar Renewable Energy Certificates (SRECs) represent the renewable attributes of solar generation, bundled in minimum denominations of one megawatt-hour (MWh) of production. New Jersey's SREC program provides a means for SRECs to be created and verified, and allows electric suppliers to buy these certificates in order to meet their solar RPS requirements. All electric suppliers must use the SREC program to demonstrate compliance with the RPS. The price of SRECs is determined primarily by their market availability and the price of the Solar Alternative Compliance Payment (SACP) for the state RPS. The SACP is effectively a ceiling on the value of SRECs because it is the per MWh payment that electricity suppliers must make if they fail to obtain enough SRECs to cover their RPS obligation.

New Jersey's renewable portfolio standard (RPS) -- one of the most aggressive in the United States -- requires each electricity supplier/provider serving retail customers in the state to include in the electricity it sells 22.5% qualifying renewables by 2021. By 2021, 2.12% solar electricity -- an amount estimated to be 1,500 megawatts (MW) -- is required in New Jersey.

Demand Response

Power plants in New Jersey constantly struggle to meet peak demand during the summer. Since electricity use is markedly higher during hot, summer days, power plants must be sized to meet needs during these peak hours. The trade-off is that most of the time, the power plants are operation at less than their peak load, thereby reducing efficiency.

Demand response programs look to mitigate peak demand by developing partnerships with industrial and commercial customers. During periods of high demand, the utility will ask the participant in the demand response program to lower their power use. Almost all utilities offer incentives for participation in demand response programs.

There are many methods by which facilities can participate in demand response programs:

- Dimming Lighting - Overhead and refrigerator cases lighting can be dimmed with out unacceptable sacrifices
- HVAC Control Set point Setback - modern energy manage-

Incentive Structure for NJ Pay for Performance Program	
Incentive #1: Energy Reduction Plan	
Incentive Amount	\$0.10 per sq ft
Minimum Incentive	\$5,000
Maximum Incentive	\$50000 or 50% of facility annual energy cost
Incentive #2: Installation and Recommended Measures	
Minimum Performance Target	15%
Electric Incentives	
Base Incentive based on 15% savings For each % over 15% add Maximum Incentive	\$0.11 per projected kWh saved \$0.005 per projected kWh saved \$0.13 per projected kWh saved
Gas Incentives	
Base Incentive based on 15% savings For each % over 15% add Maximum Incentive Incentive Cap	\$1.10 per projected Therm saved \$0.05 per projected Therm saved \$1.45 per projected Therm saved 30% of total project cost
Incentive #3: Post-Construction Benchmarking Report	
Minimum Performance Target:	15%
Electric Incentives	
Base Incentive based on 15% savings For each % over 15% add Maximum Incentive	\$0.07 per projected kWh saved \$0.005 per projected kWh saved \$0.09 per projected kWh saved
Gas Incentives	
Base Incentive based on 15% savings For each % over 15% add Maximum Incentive Incentive Cap	\$0.70 per projected Therm saved \$0.05 per projected Therm saved \$1.05 per projected Therm saved 20% of total project cost
Advanced Measure Incentive: Combined Heat and Power	
Eligible Technology	Incentive (Max: \$1 Million) Maximum % of Project Cost Minimum System Size
Level 1	
Fuel cells not fueled by Class I renewable fuel	\$4 per Watt 60% None
Level 2	
Microturbines, Internal Combustion Engines, Combustion Turbines	\$1 per Watt 30% None
Level 3	
Heat Recovery or other Mechanical Recovery from Existing Equipment	\$0.50 per Watt 30% None

ment systems allow for easy and temporary set-point changes that are triggered by a signal from the utility

- Use of Facility Backup Generator - Back-up generators can be run for short periods of time if they are fitted with environmental modifications, such as catalytic converters. Always check with the appropriate regulatory agencies (NJDEP) before running your generator for non-emergency purposes.
- Facility Process Shutdowns - in the most dramatic case, the facility would shut down – not an attractive option for supermarkets, but with the right incentive may be worth it.

For more information about demand response programs available in your area, please find the contact information for your utility on the following website:

<http://www.pjm.com/markets-and-operations/demand-response/csps.aspx>

Energy Aggregation

New Jersey allows customers to purchase their electric generation from competitive third party suppliers (“TPS”). TPS offer electric rates to commercial customers under short or long term contracts. Customers can save money if the TPS can sell the power below the rates that the utilities charge for electric supply service.

Now is a good time to shop for electric savings. For most customers, the electric market offers competitive prices from TPS as compared to the rates that the utilities charge. Electric prices have declined over the past 6-8 months due to the slowdown in the economy, which has reduced demand for electricity and natural gas as a primary source for electric generation. Supermarkets should contact TPS to see if they can offer a price for your electric supply service that will provide savings versus utility rates.

Contact information on TPS serving the New Jersey market can be found at the New Jersey Board of Public Utilities website:

<http://www.nj.gov/bpu/commercial/shopping.html#2>

Supermarkets should also look to join trade association electric aggregations, which buy electric in bulk to obtain greater savings and more favorable contract terms through their collective buying power. For example, the New Jersey Food Council has an electric aggregation and participating members are saving money on their electric bills due in large part to the size and number of participants. Contact trade associations of which you are a member to see if they have an electric aggregation you can join. Supermarkets should seek to save money on their electric bills, whether buying power on their own, from a TPS, or with an aggregation.

Environmental Considerations

Concerns about leaking refrigerants are paramount in the supermarket industry, and sometimes require a sacrifice of energy efficiency. Using modern technologies, new design strategies, and good operational practices, one can mitigate these concerns, and perhaps even offer an opportunity for energy savings.

Simple purging of refrigerants (R11, 12, 21, 22) was common years

ago as a method of ensuring that air and humidity were removed from a refrigerant system, but this practice is a relic of the past. Extreme care is now the norm when handling refrigeration systems. From a design standpoint, if building a supermarket from the ground up, the ideal scenario involves minimizing refrigerant line runs. Traditionally, the buildings were designed for ease of maintenance, putting the compressors in one or two rooms, and running the lines to the remote cases. Putting the equipment in one location is still an option, but instead of running refrigerant lines out to the cases, an intermediate heat transfer fluid (usually a glycol solution) is used, keeping the refrigerant lines short. The other option is to put the compressors on the roof directly over the cases, which provides short line runs, but makes maintenance a little more inconvenient. More detail on various new refrigeration setups is provided in the following Chapter.

Greenhouse Gas Equivalencies

Greenhouse gases come in all shapes and sizes. While CO₂ is the predominant human-caused greenhouse gas, many other chemicals contribute significantly to global warming.

Global Warming Potential (GWP) is a measure that is baselined to carbon dioxide and measures the global warming effect of a substance per unit mass. For example, methane has a GWP of 23. If you release one pound of methane into the atmosphere, it would be the equivalent of releasing 23 pounds of carbon dioxide.

The Total Equivalent Warming Impact (TEWI) represents the sum of the direct and indirect emissions of greenhouse gases of a product or process. For example, refrigeration systems can directly contribute to warming through the leakage of HFC's, and indirectly contribute to warming by consuming electricity fed by a GHG emitting power plant. TEWI will be used later in this manual when comparing refrigeration systems.



3 Energy Saving Opportunities

What are 'Energy Saving Opportunities'?

This section outlines the many energy saving opportunities that may be available in your municipality buildings and facilities. The sections are broken down into major energy consuming systems applicable to your specific industry. Case studies will be shown to help solidify the presented concepts.

While renewable energy systems are important components of a sustainable society, they can only be successful in a culture that promotes conservation and efficiency. These recommendations are relatively low cost, easy to implement solutions that help save energy in your facility buildings while setting the example for the rest of the community.

Lighting

Lighting is a huge consideration and energy factor in modern supermarkets. Not only do supermarkets need to be well lit for customers late through the night, but light is needed for refrigeration and display cases, and needs to be efficient and effective in selling the product. There are many factors that need to be taken into account in terms of lighting; for example, certain color lights make produce and deli meats more appealing to customers. Fluorescent lamps colors are rated from "warm" (3000°K) to "cool" (6000°K).

On an energy level, in refrigerators alone, lighting accounts for 15% of the total energy consumed. One of the greatest challenges in a supermarket is finding a comfortable level of lighting for customers while providing the greatest efficacy (ratio of light to energy consumed) possible in order to conserve energy and money. Supermarkets set their objectives to make their stores look bright and open, as well as make their merchandise look appealing, reduce glares on cases, and lower light levels in order to save energy.

Inside a supermarket there are basically four types of lights:

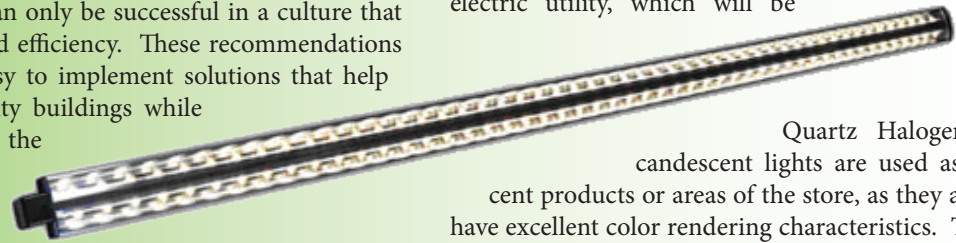
- High bay lighting
- Ceiling height or Aisle lighting
- Display case lighting
- Spot lighting

Lighting manufacturers are bringing exciting new products to market with both higher efficiency and acceptable Color Rendering characteristics.

High bay lighting is typically of the High Intensity Discharge (HID) variety, usually High Pressure Sodium or Metal Halide lamps. At ceiling height, fluorescent lighting has been the unit of choice for many years now, and still is an excellent selection. In recent years, electronic ballasts have been developed that not only make the lighting system more efficient, but allow for dimming capabilities. Dimming can be used when the area is well lit by the sun, for example at the front of the store, or it can be used in con-



junction with the natural lighting of skylights. Recently, dimming ballasts have been developed for HID lighting, allowing them to be dimmed up to 50%. Dimming can also be used as part of a "demand response" program with the electric utility, which will be discussed later.



Quartz Halogen and some incandescent lights are used as spotlights to accent products or areas of the store, as they are very bright and have excellent color rendering characteristics. These can easily be dimmed. The HID lighting mentioned earlier is the type that takes several minutes to warm up, so they are rarely turned off. However, new technology has evolved that allow them to be dimmed to 50%.

EXAMPLE: Metal Halide to T5 Fluorescent Switchout

There are several advantages in changing from metal halide (MH) to T5 fluorescent lighting. A one-to-one switchout from 400W MH fixtures to 4-lamp T5 fixtures is possible (23,000 mean lumens compared to 20,000 mean lumens, respectively). T5s also have a higher color rendering index (CRI) value (85 vs. 65) for truer color visibility. Additionally, substantial energy savings are attainable as demonstrated in the following sample calculation:

$$ES = \{[(W_{MH} \times N_{MH}) - (W_{T8} \times N_{T8})] \times H \times C\}$$

$$ES = \{[(458 \text{ W} \times 100) - (234 \text{ W} \times 100)] \times 8,760 \text{ h} \times (1 \text{ kW}/1000 \text{ W})\}$$

$$ES = \mathbf{196,224 \text{ kWh}}$$

- ES → Energy savings, kWh/yr
- WMH → Current wattage of existing metal halide fixture
- WT8 → Wattage of proposed 4-lamp T5 fixture
- NMH → Number of current metal halide fixtures
- NT8 → Number of proposed 4-lamp T5 fixtures
- H → Number of operating hours
- C → Conversion from watts to kilowatts, 1000W=1kW




Based on a \$0.10/kWh unit cost of electricity and \$10/kW demand cost, expected annual savings are **\$22,310**.

Light emitting diodes are the lighting of the future. They have been used in small lighting situations for years, but they are now being developed for other uses such as refrigeration and freezer display cases. Not only are they more economical to operate, but they last as much as ten times longer than the fluorescent lights they replace and they are not affected by cold or shock. Whereas fluorescent lamps must be placed at the hinge of the door where the light is unevenly distributed the LEDs can be placed under shelves, for better distribution of light. The savings are not only in the light, but also because the reduced heat load makes the compressors run less often. Since they produce less heat, there is less spoilage and “burn” compared to other types of light.

with the proper operation. Dehumidification is necessary when the relative humidity in the space rises above 55%; however studies in Germany have suggested that lower humidity can save energy by reducing the cycle time of the compressors as well as the defrost cycle. One way to accomplish this is by “splashing” cold dry air into small areas of the store where it will not cause discomfort to the customers. This dehumidification can be accomplished by normal air conditioners, but due to the higher ventilation rates that have been adopted in recent years; the more common approach is to use a desiccant dryer. A desiccant is a material that removes moisture from the air when the weather is humid. Heat is then required to re-dry it when saturated, so it can be used again. This heat is often provided by a natural gas or electric

heater. But due to rising energy costs, other heat sources have been used, which will be discussed later.

One ASHRAE study (Humidity Effects on Supermarket Refrigerated Case Energy Performance: A Database Review; Douglas Kosar Octavian Dumitrescu) concludes that lowering the humidity is acceptable to customers and saves energy.

ANNUAL OPERATING COST COMPARISON FOR RECESSED DOWN LIGHTING					
LIGHT SOURCE	LIGHT OUTPUT (LUMENS)		WATTS	LIFETIME (HOURS)	ANNUAL OPERATING COSTS*
	USEFUL LIGHT	WASTED LIGHT			
 Incandescent bulb	575	575	75.0	1,000	\$8.87
 Compact fluorescent light bulb (CFL)	575	575	20.0	10,000	\$2.37
 ENERGY STAR qualified LED lighting	575	0	16.5	25,000 or 35,000	\$1.95

Courtesy: “ENERGY STAR® Qualified Lighting 2008 Partner Resource Guide.”

Heating, Ventilation, And Cooling

Heating

The heating of a supermarket in New Jersey is fairly simple and straight forward. There is a lot of internal gain in a supermarket due to compressors, lights, and other heat loads. There is a significant amount of heat that is required by ventilation requirements to satisfy the American Society for Heating, Refrigeration, and Air Conditioning (ASHRAE) air quality standards. Most heating is done by natural gas heaters, where gas is available.

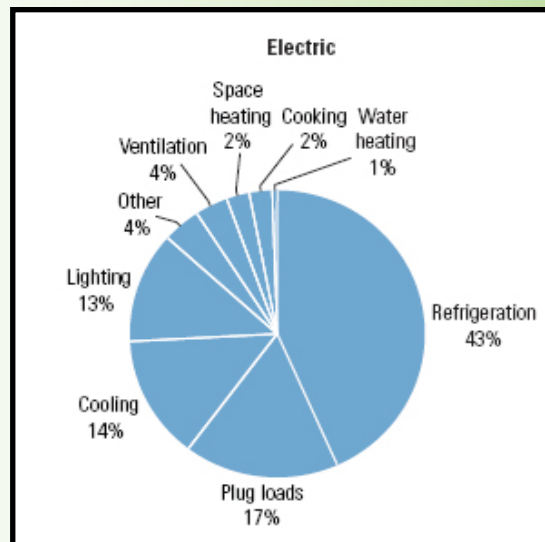
Cooling and Dehumidification

Cooling and dehumidification are a much larger issue than heating, as moisture in the air will condense on the glass of cooler cases and freezers, and can freeze on the evaporation coil of the refrigeration units interfering

Refrigeration

Refrigeration and freezing cost, on average, almost 50% of a supermarket's electricity bill, depending on climate zone. Attention to these devices and peripheral equipment is critical to saving energy in supermarkets.

Fortunately, much work has been done in this area. While the basic compressor has not changed much for 20 years, much else has. In particular, refrigeration cases have gotten more efficient, using better insulation, doors, and much more. The load that is placed on the compressors comes from two sources; outdoor temperature



Typical Supermarket Energy Use
Courtesy: “ENERGY STAR® Building Manual”, Revised Jan. 2008

and humidity, and indoor temperature due to internal heat loads, such as compressors. The purpose of the condensers is to reject heat. This heat traditionally was rejected to the environment, and this is still very common, but since this heat is “free”, the real opportunities lie in recovery and use of this heat, especially in the summer. These technologies, called de-super heaters; have been developed to take advantage of this heat. One use is to preheat the Domestic hot water that the facility uses.

Another use for this heat is to dry the desiccant dehumidifiers. As mentioned earlier, these devices, which dry the fresh air that is injected into the store, require heat to “regenerate” the system, thus discharging the humidity to the outdoor air. One of the beauties of this set-up is that the heat can be used for both purposes, since hot water use is generally very limited. That is, a substantial amount of hot water is used at certain times, for example when the shift changes occur, to wash up and sanitize equipment.

Lowering the temperature in the store would take some load off the refrigeration case, but would be unacceptable from a customer standpoint. These savings come from both lower product requirements and decreasing the defrost cycle. It is also possible that glass door heaters for defogging could be discontinued. This heat, which must be disposed of, can be used for several opportunities. Often there are two compressor rooms, so the heat from the other compressor bank is still available. But even if that were not the case, the hot refrigerant can be used both for domestic hot water use and then for heating of the desiccant drying wheel, since hot water use is sporadic and tends to be needed in large amounts for wash-down at the end of the shift. In fact, this saves energy at the compressor, since heat removal by the water is better than rejecting to the ambient air.

Probably one of the best energy savers for stores that are not open 24 hours a day are thermal shades. Aluminum shields can cover the front opening of the display case and reduce the radiative and convective heat transfer into the case, thus reducing the power use while improving the product temperature maintenance. A controlled study by the Refrigeration Technology and Test Center of Southern California Edison Utility, shows that facilities that use aluminum shields during closing hours (approximately 6 hours a day) lowers the average product temperature by 4%, the refrigeration load by 12.6%, and the compressor power consumption by 9%. By using these shields on store closing holidays, the facility can lower average product



Ground-Source Heat Pumps

Although the first time cost is currently around 85% more expensive per ton of refrigeration unit compared to a standard AC system, energy savings have been estimated to be around 50% over standard AC systems. Recent installations include a 75 ton system for the 50,000 ft² First Americans IGA Supermarket in Akwesasne, New York.

temperature by 11%, refrigeration load by 41%, and compressor power consumption by 36% on these days. Thus, it is highly recommended that the supermarket use aluminum shield during non business hours to reduce energy costs and improve overall competitiveness of the facility.

Building Design Considerations

Most buildings were not designed to be supermarkets, but simply a shell that is customized for a tenant. However, if given the opportunity to design a building for the supermarket sector, there are several factors and technologies that can be taken into consideration.

Geothermal Heat Pumps

Geothermal (Ground-Source) heat pumps have been used since the 1940s and can substantially reduce energy consumption in Heating, ventilation, air conditioning (HVAC) as well as refrigeration. Geothermal systems take advantage of the consistency in ground temperatures; below a certain depth, the ground temperature remains constant throughout the year in the New Jersey geographic area. In the summer and for refrigeration applications, this can be used as a heat rejection sink while in the winter, the ground can be used as a heat source. Geothermal heat pumps can be used for both combined heating and cooling, ideal for a supermarket as it can displace some of the refrigeration cost while providing heating for store comfort.

Other Design Considerations

Other design considerations include constructing the roof structure with enough strength to support a Solar Photovoltaic system to produce electricity. In a recent retrofit application, structural improvements almost doubled the cost of the installation. This is also true of the strategic placement of refrigeration to reduce the amount of refrigerant in the system and the likelihood of leaks. Location of the coolers and freezers can be grouped to minimize the length of refrigerant lines, although their placement is usually dictated by customer preference and sales strategies. However, placement of conflicting uses, such as ovens near freezers might be possible. Although not strictly an energy play, many stores have dual wiring for the electricity, so that one can be operated with an uninterruptible power supply for the computers, cash registers and other sensitive equipment.

For more information on building design considerations, please refer to the follow references:

- *Information for Evaluating Geoexchange Applications* prepared for NYSERDA by the Geothermal Heat Pump Consortium, 2007.
- “How to Buy an Energy Efficient Ground Source Heat Pump” EERE (http://www1.eere.energy.gov/femp/procurement/eep_groundsource_heatpumps.html)
- “Selecting and Installing a Geothermal Heat Pump System” (http://apps1.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12670)

Novel Supermarket Refrigeration Setups

(Courtesy of: Oak Ridge National Laboratory, "Advances in Supermarket Refrigeration Systems")

While most supermarkets today use a traditional multiplex refrigeration system, recent advances in system controls and design have enabled systems that have many benefits over conventional systems, including energy efficiency, refrigerant use, and temperature set point customization.

Conventional Multiplex Systems

Conventional supermarket refrigeration systems were developed with convenience, not efficiency, in mind. A typical 3,720 m² supermarket with a multiplex system requires 1,300-2,500 kg of refrigerant (at an average annual leakage rate of about 30%), and consumes about 976,800 kWh of electricity annually.

Low-Charge Multiplex Systems

A refrigerant "charge" is an industry term that refers to the total mass of refrigerant in a system. Through the use of modern control systems, Low-Charge Multiplex Systems can reduce total system charge by one third or more.

Secondary Loop Systems

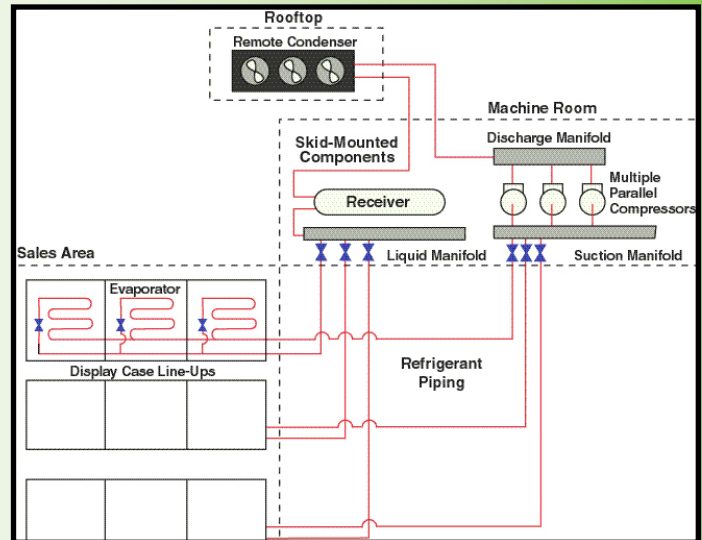
'Secondary Loop' refrigeration systems seek to limit the total amount of refrigerant used in a system (the refrigerant 'charge'). By employing a standard refrigerant loop and at least one secondary brine solution loop, the total amount of refrigerant used is reduced to about 15-25% that of a conventional multiplex system.

Energy savings can also be realized if a significant portion of cooling needs can be met by a relatively high temperature cooling loop (-18 degrees Celsius to -1 degrees Celsius). By matching secondary loop temperatures to needs directly, the cooling system can be optimized energetically.

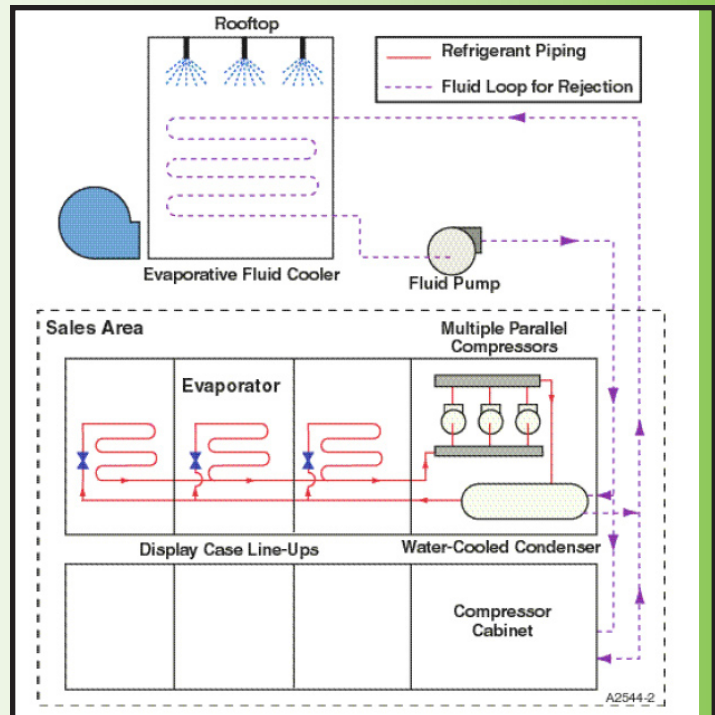
Distributed Compressor Systems

Another method to reduce refrigerant charge is to employ a distributed compressor system. Distributed compressor systems utilize multiple, small compressors set up near the loads they serve. By limiting long runs of refrigerant piping, the total refrigerant charge is reduced to 30-50% of a traditional multiplex system.

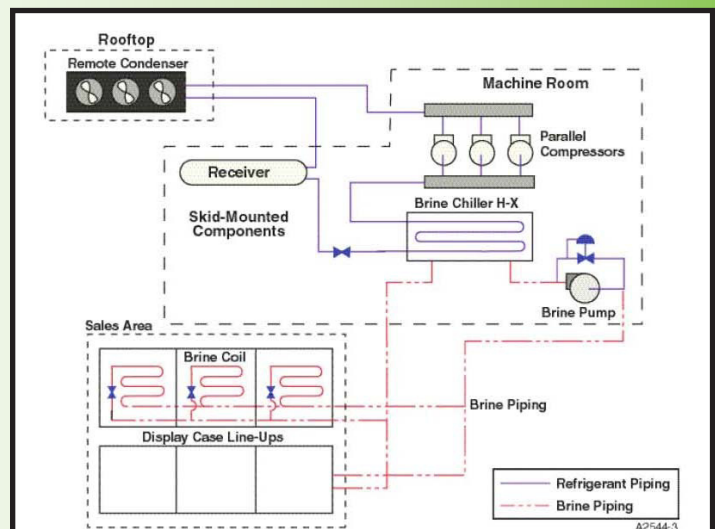
Distributed compressor systems usually utilize scroll compressors due to their low noise and vibrational levels. While they are in general less efficient than reciprocating compressors, this is at least partially offset by the ability of scroll compressors to operate at lower condensing temperatures, usually around 15 degrees Celsius.



Conventional Multiplex System



Distributed Compressor System



Secondary Loop System

Comparing Refrigerant Systems: Energy savings and TEWI

When fully analyzing the environmental impact of a refrigeration system, one must take into account the ecological impact of both energy use and refrigerant leakage. TEWI allows us to examine both of these factors along the same baseline. The following figure shows a study by the Oak Ridge National Laboratory comparing various refrigeration setups.

As one can see, distributed systems have very similar TEWI to secondary loop systems. Naturally, a water-cooled chiller produces less greenhouse gases because of its increased energy efficiency.

System	Condensing	Charge, kg/kW	Primary Refrigerant	Leak (%)	Annual kWh	TEWI (million kg of CO ₂)		
						Direct	Indirect ^a	Total
Multiplex	Air-Cooled (baseline)	4.15	R404A /R-22 ^b	30 (15)	976,800	13.62 (6.81)	9.52 (9.52)	23.14 (16.33)
	Evaporative	4.15		30	896,400	13.62	8.74	22.36
Low-Charge Multiplex	Evaporative	2.77	R404A /R-22 ^b	30	863,600	9.08	8.42	17.50
				15	863,600	4.54	8.42	12.96
Distributed	Water-Cooled, Evap	1.24	R404A	5	866,100	1.00	8.44	9.44
Secondary Loop	Evaporative	0.69	R507 ^c	10	875,200	1.13	8.54	9.67
				5	875,200	0.56	8.54	9.10
	Water-Cooled, Evap	0.27	R507 ^c	5	987,900	0.23	9.63	9.86
				2	987,900	0.09	9.63	9.72

Operations and Maintenance

Proper Operations and Maintenance is always important from an energy and environmental stand point. Many stores are now having their HVAC contractors install “super hoses” on their compressors. These are seamless hoses that have special fittings that are designed to leak less (or none) refrigerant.

The size, shape and placement of shelving in a cooler or freezer case are all part of the design. They must be lightly cleaned at least monthly, along with all evaporator coils; and they must be intensely cleaned annually. Interference with the air flow in an upright case will cause cold air to fall to the floor, wasting energy, and also can cause the product to thaw or spoil.

The following page contains a checklist of common maintenance and operational procedures for supermarket equipment. Following this assessment checklist will help to maximize equipment life and energy efficiency.

Energy Assessment Checklist

The following document was developed by the Nebraska Public Power District for self-assessment of supermarkets by managers. It is a very helpful resource for identifying and dealing with the “low hanging fruit” of energy savings that are typically available within a supermarket facility.

Refrigeration - Operation

- Keep cold air supply and return registers clean and clear of product.
- Maintain minimum recommended refrigeration temperature for produce.
- Optimal refrigeration efficiency is achieved with ambient air relative humidity levels between 40-55%.
- Identify feasibility of venting or recovering the rejected heat off the refrigeration units condensers.

Refrigeration - Maintenance

- Check for unusual noise, vibration and decrease in performance of compressors/motors.
- Clean refrigeration coils regularly.
- Replace worn and/or leaky door seals.
- Verify operation and efficiency of defrost timers and moisture sensors to ensure optimal performance.
- Clean and disinfect condensate drain pans.
- Monthly/bi-monthly maintenance contract.

Refrigeration - Procedures

- Follow manufacturer’s recommendations for shelf position and size.
- Keep upright display case doors shut.
- Rotate stock regularly.
- Do not let refrigerated items sit and warm-up during delivery and/or restocking.
- Turn off refrigeration unit when not in use.

Heating, Ventilation and Air Conditioning (HVAC) - Operation

- Winter recommended temperature, 60°F.
- Winter recommended setback temperature, 50°F.
- Summer recommended temperature setting, 78°F with 55% relative humidity.
- Monitor make up air ventilation (15 cfm/person required).
- Avoid heating and cooling at the same time.
- Use timers for start/stop cycles.
- Utilize programmable thermostats to maximize comfort and efficiency.

Heating, Ventilation and Air Conditioning (HVAC) - Maintenance

- Replace furnace filters on a monthly or bi-monthly schedule.
- Allow free airflow to and from registers.
- Install vinyl curtains in loading areas.
- Insulate doors, hot water heaters) and pipes, and ductwork located in unconditioned areas.
- Cover and lock thermostats and ventilation controls to prevent unauthorized adjustments.
- Check for unusual noise, vibration and decrease in performance or compressors/motors.
- Seal ductwork leaks.
- Inspect/clean condenser coils.
- Clean and disinfect condensate drain pans.
- Set up monthly/bi-monthly maintenance contract.

Heating, Ventilation and Air Conditioning (HVAC) - Procedures

- Minimize heating and cooling in unoccupied, low-traffic areas or when building is not in use.
- Adjust building temperature by season; lower in winter and higher in summer.
- Utilize ceiling fans whenever possible.
- Advise employees to dress appropriately for seasonally maintained building temperature.
- Close doors to outside and unheated or uncooled areas.
- Use exhaust ventilation only when required.
- If fossil fuels are present, test operation of carbon monoxide (CO) detectors monthly.

Lighting - Operation

- Use automated lighting controls.
- Utilize photocells for all-night outdoor lighting.
- Use timers in parking lots and restricted-access areas.
- Utilize dimming controls to take advantage of daylighting.
- Use motion sensors for low-traffic areas.
- Always de-energize ballasts that are not in use.
- Lamps with a color rendition index of 80 or more provide the best color for produce and meat sections.
- Verify recommended illumination levels.
- Reduce lighting to minimum acceptable level for safety/

security in: hallways, restrooms, storeroom and coolers.

Lighting - Maintenance

- Clean lamps and fixtures for maximum illumination.
- Repair/replace broken fixtures.
- Replace non-working lamps with the lowest wattage available while maintaining lumen output.
- Develop and implement a lamp upgrade program to energy efficient lighting (T-8, compact fluorescent, etc.).
- Add reflectors to existing lighting.
- Label panels and switches so lighting can be monitored and controls can be accessed.

Lighting - Procedures

- Turn off lights not being used.
- Use task lighting in place of area lighting where possible.
- Open drapes/blinds and use natural lighting when possible.
- Designate and light only specific parking areas for use.
Use decorative lighting and electrical signs only during high-traffic hours.

Bakery - Operation

- Preheat ovens only when necessary and set to minimum preheat temperature.
- Turn off or reduce temperature of fryers during low demand periods.
- Slow down or turn off exhaust hoods during slow food preparation periods.

Bakery - Maintenance

- Make sure oven doors close and seal properly.
- Clean ovens regularly.
- Verify thermostat accuracy and recalibrate if necessary.
- Keep gas appliance's orifices free of debris.

Bakery - Procedures

- Bake during off-peak cooling periods when possible.
- Bake foods needing lowest temperature first.
- Bake in large volumes.
- Provide adequate space between pans and oven walls.
- Load and unload ovens quickly to avoid heat loss.

- Turn off oven shortly before baking time is complete and keep door closed to maintain temperature. **13**

Building Envelope

- Check and verify insulation levels.
- Fill in outside air leaks with a low expanding foam.
- Replace cracked or missing window and door caulking.
- Install solar film or blinds for windows with east, west or south exposure.
- Replace cracked or missing weather-stripping.

If you have any questions regarding any part of this document, please contact the Center for Advanced Energy Systems. Contact information is available at <http://caes.rutgers.edu>

