

Capturing Financial Savings through Energy Efficiency in Commercial Refrigeration

By Paul Nastari

Designing energy efficiency into refrigeration systems can differentiate consultants and designers from their competition, result in larger contracts and pay back the initial cost to the customer in just a few months of operation.

With so much current interest in going green and being conscious of our effect on our environment, you can find Energy Star miser machines bursting with tax credit karma and rebate repertoires on virtually every piece of kitchen equipment imaginable. That is, everything except some of the largest pieces of equipment – walk-in coolers and freezers.

The Energy Star program estimates upgrading to newer and more efficient components can save roughly 25% of the \$1 billion spent on energy use by commercial refrigeration. Additionally, that 25% equals a yearly reduction of 475,000 cars in the U.S. alone. The payback period to commercial refrigeration customers for these changes ranges from roughly one to three years, a short enough period of time for the effect to be seen on the monthly balance sheet. Certainly, this wouldn't interest you if you're designing a five year kitchen. However, if you are designing a ten year kitchen the ROI can be staggering without any tax credits or rebates.

So with these benefits being so obvious, why aren't we seeing faster adoption of highly efficient designs in refrigeration?

Answer: Because we have to change our design habits to make the difference. We need to become familiar with new components, new design techniques and the convoluted system of local, state and federal rebates available to customers. Fortunately, all the ingredients to effect these changes in habit are now available and we can begin using them today.

First, let's take a look at the energy-efficient components that comprise a system that can qualify for energy-efficiency rebates.

EC Motors Are Efficient And Now They Are Also The Law In California

Electronically Commutated (EC) motors are so efficient and such an obvious solution to gaining energy-efficiency that California now requires them to be used in all new walk-in coolers and freezers. This is not just another "expensive" trend attempting to simulate energy efficiencies. EC motors will actually compound the cost savings because they emit less heat than either typical Shaded Pole or Permanent Split-Capacitor (PSC) motors. Reducing the heat load inside of the walk-in effectively reduces the compressor's run time. Fewer refrigeration cycles not only saves energy it extends the life of the compressor as well. More government bodies will explore the standard set by California and it is likely that EC motors will quickly replace Shaded Pole and PSC types. At least two more states are considering the implementation of energy efficiency requirements similar to those of the CEC in 2009.

Current EC motors operate at approximately 85% efficiency. This makes EC motors 50-60% more efficient than the older Shaded Pole motors and 30% or more over PSC motors. These efficiencies quickly add up to real cost savings when applied to the 50-85 watt motors capable of turning the 10-18-inch fans producing the higher airflows required to effectively cool walk-in coolers and freezers. EC motors are also available with microcontrollers for precisely matching environmental requirements which constantly vary.

Designing refrigeration systems with EC motors is relatively easy: a change in nomenclature simply replaces the current choice of Shaded Pole or PSC motors. No changes in design are required past specifying the

Projected Energy Savings for Typical Applications on New Equipment*						
Equipment				EC vs. Shaded Pole Motors		
Application	Description	Total Qty. Evaporators	Total Qty. Motors	kWh/Yr	\$/Yr*	Payback (months)
Supermarket/ Grocery Store	2 Freezers; 9 Coolers	12	37	22,154	\$1,994	28
Wholesale Club	3 Freezers; 7 Coolers	25	99	68,573	\$6,172	25
Convenience Store	2 Freezers 1 Cooler	5	9	4,649	\$418	31
Full-Serve Restaurant	1 Freezer 2 Coolers	3	9	5,148	\$463	29
Quick-Serve Restaurant	1 Freezer; 1 Cooler	2	6	4,598	\$315	28

*Based on InterLink EC motors. Copyright Heatcraft World Wide Refrigeration.

motor, especially since the electrical requirements will be lower with EC motors. EC motors are designed to be compatible with existing evaporator cabinets without any change in physical dimensions. Rebates are available for retro-fitting EC motors in California.

Demand Defrost Technology Works to Maintain Product Quality

Demand defrost (aka Smart defrost) wins big in two ways: First, the number of defrost cycles are matched to the refrigerated environment's need, eliminating the cost of unnecessary defrost cycles; secondly, product quality is more easily maintained because it is subjected to fewer defrost cycles.

According to Intertek Testing Services, a third-party testing laboratory, as many as 43.6% of defrost cycles can be skipped using a microprocessor-controlled system (measured using the Interlink Smart Defrost Kit working in conjunction with an existing defrost time clock). The microprocessor bases defrost cycles on a sophisticated statistical model and the actual defrost requirements of the evaporator coil. New demand defrost designs that replace the defrost time clock with a microcontroller-based system and monitor the evaporator can reduce the number of defrosts by up to 75% (e.g. Beacon II Smart Defrost). It's hard to deny that this is pretty "Smart!"

Each refrigeration system has specific cooling needs that vary based on humidity, door openings, location, altitude, and a number of other factors. Timed defrost cycles ensure that defrosting occurs, but the cycle activates according to a clock and not according to need. Demand defrost uses multiple sensors in different areas of the evaporator assembly, a defrost cycle will kick in only when the microcontroller determines a defrost is required. Measurement of the defrost requirements uses learned information gathered on each defrost cycle and compares this to the built-in statistical modeling, then the system makes a decision whether to begin a defrost cycle.

It is no surprise that product quality is more easily maintained through consistent temperature and, although very important to overall system performance, temperature variations introduced through defrost cycles can easily affect product quality. Limiting defrost cycles to a minimal number by using complete system monitoring and measurement will result in product quality maintained in a constant state. Product quality attributes most

ENERGY SAVINGS OF ELECTRONICALLY COMMUTATED (EC) MOTORS Vs. SHADED POLE & PERMANENT SPLIT CAPACITOR (PSC) MOTORS				
	SHADED POLE MOTORS		PSC MOTORS	
	kwatt hrs/yr savings	\$/yr* savings	kwatt hrs/yr savings	\$/yr* savings
OFF CYCLE/AIR**				
Motor Wattage Difference	1069	\$ 96.00	491	\$ 44.00
Load Reduction	462	\$ 12.00	212	\$ 6.00
TOTAL SAVINGS	1531	\$ 108.00	703	\$ 50.00
ELECTRIC**				
Motor Wattage Difference	962	\$ 87.00	442	\$ 40.00
Load Reduction	670	\$ 18.00	308	\$ 8.00
TOTAL SAVINGS	1632	\$ 105.00	750	\$ 48.00

* \$.09 per kwatt used for cost.
 **Evaporator Systems Used: Low Profile LSC120AK for Off Cycle/Air defrost; Low Profile LSF090BK for Electric defrost.

affected by changing temperature are moisture content and volume shrinkage; both factors can limit the amount of product sold and the value of the product being sold.

Maximum Efficiency By Design

We design a kitchen, a restaurant, a cafeteria, or any other foodservice area to make the most efficient use of space and traffic flow patterns. We can significantly reduce energy use and lower operations costs by using the same thinking in design of the refrigeration systems themselves. Using proper placement and installation techniques can raise the efficiency of the refrigerated system and the entire foodservice area.

One obvious opportunity to raise efficiency and enhance the kitchen environment is by using split system refrigeration. While self-contained systems seem to be a simple solution to refrigeration design, they cost more initially, as much as 47% more on an average freezer, and have higher maintenance costs. A self-contained system is usually located on top of the walk-in unit inside of the building, sometimes in the kitchen itself. It pumps the heat from the refrigerated space into the surrounding area, actually adding heat to the kitchen and requiring the system to work harder. At the very least the HVAC system will be required to run longer in order to remove the additional heat load that a self-contained refrigeration system dumps into the kitchen.

ENERGY SAVINGS EXAMPLES*			
Low Profile, Medium Profile and Large Unit Coolers w/electric defrost and the Beacon II™ Smart Defrost system operating at 90F cond. & -20F @ \$0.08/kwh.			
	Low Profile Evaporator	Medium Profile Evaporator	Large Unit Cooler
Evaporator	12000 BTUH	33000 BTUH	144000 BTUH
Condensing Unit	3 HP	7.5 HP	30 HP
Heater Watts	2.7 KW	7.8 KW	37.1 KW
Compressor Watts	2.7 KW	5.6 KW	18,3 KW
Defrosts per Day	1	1	2
Estimated Yearly Savings	\$163	\$704	\$2,053

*Results may vary depending on application conditions. Calculations for the Low Profile and Medium Profile are based on actual data from systems running in a single location in the U.S.A. Data for Large Unit Coolers are projected.
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Self-contained systems are purchased as a part-numbered item and rarely satisfy the product load requirement of the refrigerated environment. This inefficiency continues to worsen over time as the unit collects kitchen grease and dirt, clogging the condenser coils. This further lowers the cooling capacity, causing the unit to run more often and quickly exceed its mechanical capability until a maintenance call is required. Self-contained refrigeration systems are easily the most inefficient commercial refrigeration systems on the market today.

Split system refrigeration places the condenser outside of the working area, and preferably outside of the building. A remote outdoor condensing unit location eliminates the heat load in the work space and increases the efficiencies of the refrigeration system. Designed to precisely match the box load requirements of the refrigerated space, split systems are less expensive initially, although that lower initial cost may be offset because the installation costs are higher.

The real efficiency of a split system comes in the continued operation and maintenance over time. The condensing unit is exposed to clean outside air, and is much easier to clean and maintain in an outside space. Removing all of the heat from the kitchen is unquestionably the most efficient system design. The differences between self-contained systems and split systems are like night and day, and so are the paybacks!

Another opportunity for efficiency and cost containment is using hard-piped refrigeration lines. There is a

trend to save installation costs by using pre-charged line sets, but these cost more to purchase and have some major drawbacks that effect efficiency and continued operation maintenance.

Pre-charged line sets come in standard lengths and that length is always too long for your intended use. You would never order a shorter length because you know that won't work. Longer line lengths have hidden effects that waste money and energy: Refrigeration systems are like heat pumps – they move heat via liquid from one spot to another. The harder the system has to pump the more energy it uses.

A compressor pumps oil along with the refrigerant gas through the lines. When the line sets are too big, too long and coiled up, it allows the oil to separate from the refrigerant. Starving the compressor of oil guarantees that it will run inefficiently. It also reduces the effective capacity of the compressor, requiring longer run times and higher energy usage. Premature compressor failures can be a predictable result.

There is no scientific way for a factory to charge a line set exactly right for maximum efficiencies. A pre-charged line set will always be over or under-charged, and in either case, the result is inefficiencies, longer run times and higher energy consumption.

While the theory behind pre-charged line sets is they cost less because they are cheaper to install, the truth is that they are much more expensive to operate by reducing efficiency and raising maintenance requirements.

Rebates and Financial Incentives

In addition to significant cost savings through using energy efficient equipment and practices, there are a series of rebates and financial incentives offered by utilities and government bodies. Unfortunately, these rebates and incentives are different and are offered by different groups in every area, but there are guides and signs to speed the discovery and application for these incentives.

One incentive program of growing importance is the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design Green Building Rating System (LEED). This program sets a third-party standard for designs and final construction, and provides immediate and measurable results, some of which are used by government and other parties for determining applicability of financial incentives and rebates. Currently, the USGBC is placing an increased emphasis on commercial kitchen design.

In the U.S., kitchens use roughly 2.5 times more energy per square foot than any other space within a commercial building. LEED is intended to help designers determine how to appropriately plan systems and space usage to maximize energy-efficiency, and this set of decisions works for spaces in older buildings as well as entire new buildings. The details of this program are wide-ranging, requiring detailed study and assistance from accredited professionals; a more complete understanding of the LEED program is available at www.usgbc.org.

As time goes on more states will adapt rebate programs to reward the use of more energy-efficient equipment. Walk-in coolers and freezers are currently being tested in anticipation of an Energy Star listing program. Current

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rebates are focused towards retrofit, but new construction and installation is the next spot to be considered, evidenced by the recent changes in California mentioned at the beginning of this article.

Canadian provinces are also heavily involved in re-

COST COMPARISON OF SELF CONTAINED VS. SPLIT REFRIGERATION SYSTEMS				
	COOLER*		FREEZER*	
	Self Contained	Split	Self Contained	Split
Cost	\$1,458	\$1,176	\$2,133	\$1,449
CFM	500	1460	900	1400
BTUH	7630	7894	5360	5625
Amps	9.3	9.4	15.3	12.8
Watts/hr	1934	1955	3182	2662

Note: Even while drawing more amps and using more watts per hour, the cooler with the split system costs less overall because of its greater cooling capacity.

*Cooler using a 1/2hp 208-1, Freezer using a 1.5hp 208-1.

bates and incentives for energy-savings measures. Manitoba has a rebate program specifically for commercial refrigeration that is leading the country, according to Canada’s Office of Energy Efficiency. Manitoba’s 24 rebates cover moving to energy efficient equipment and technology upgrades.

In Europe, the EC is revising and enlarging their directive 92/75/EC, which now may include commercial refrigeration, and is intended to help guide member state rebate policies. The World Green Building Council, known as WorldGBC, has grown to encompass councils in 10 countries as far flung as the Japan, India, U.A.E., the U.K., and the U.S. Each of these individual country councils is developing plans and bringing their respective building policies into line with the best thinking available on sustainability practices and energy efficient design.

Conclusion

Simply put; energy-efficiency is not just a trend and it is no longer a nice-to-have. Energy-efficiency has become a measurable result of design and specification decisions. There is a growing body of financial incentives as well as government requirements.

We now have available the technology in mechanical components to help conserve energy on walk-in cooler and freezer systems. The best part about these components is that cost-recovery is easily in the range of months and not measured out beyond the life of the facility

design. An additional advantage is that the technology preserves product quality better than previous generations of technology, producing an additional cost savings beyond energy costs.

Lastly, projects using energy-efficient mechanical components and design rules pass on savings that appear immediately as rebates and incentives; energy cost-savings seen monthly; and maintenance cost-savings seen over the life of the project. The final results of energy-efficient walk-in cooler and freezer system design should be repeat clients bringing in additional projects—a greater sense of satisfaction knowing that your work is helping reduce the stress we all place on the environment.

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