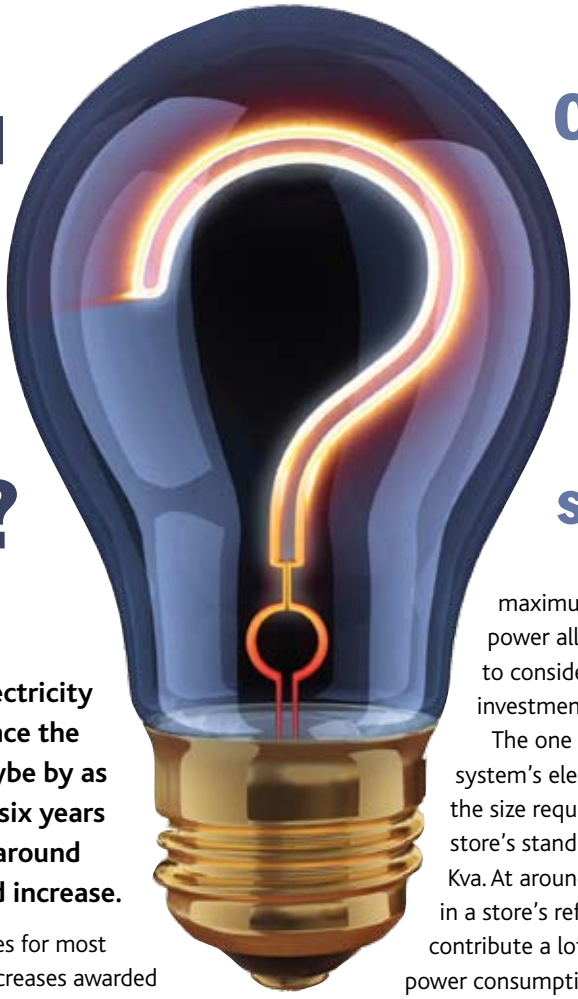
Can you keep energy costs down?



Configure your refrigeration for a new era of costly electricity and uncertain supply

By Stephen Maister

You may have noticed that your electricity account has climbed quite a bit. Since the rolling blackouts of April 2008, maybe by as much as 45%. Certainly in the last six years the average cost has jumped from around 15c to 60c a KWh – a mere fourfold increase.

It's now sitting around 1.5% to 2.5% of sales for most supermarkets. The 25% odd annual price increases awarded to Eskom over the next three years is going to almost double it again. Electricity is now about the third biggest item on a store's profit & loss account after rent and staff costs.

With refrigeration now accounting for up to 70% of a store's electricity bill, its efficiency has a major impact on store profits.

Then there's the uncertainty of supply. Eskom is asking us to survive the World Cup with just the TV set and one light on. Rolling blackouts are expected to be the order of the day from 2011 onwards. So, get ready to crank up that standby generator once again. If there is one thing worse than paying Eskom's tariffs, it's the cost of producing your own power at about ten times more. Three days on standby generators could double your monthly electricity costs. And there's one more thing going forward that may be worse than an erratic electricity supply – that is no supply, or a greatly reduced maximum demand over peak periods for new stores or stores wishing to expand their size.

Capital costs and the cost of power saving interventions

There is a wide variety of interventions available today that improve the efficiency of refrigeration and save power. All can be built into new refrigeration installations and many can be retrofitted onto existing ones.

This increased sophistication mostly comes at significantly increased costs. Access to capex in the first place, its cost and what is considered to be an acceptable payback period will help determine what any store operator will be willing to invest in improved refrigeration efficiency. In addition to where you may be forced to spend more than you would wish when faced with a reduced maximum demand over peak periods power allocation, there are two other things to consider in making these refrigeration investment decisions.

The one is that reducing the refrigeration system's electricity requirement also reduces the size requirement and with it the cost of the store's standby generator. Generators are rated in Kva. At around R1 000 a Kva, a sizable reduction in a store's refrigeration power requirement can contribute a lot to the cost of reducing refrigeration power consumption. In some cases it may even directly pay for it. The long-term benefits are the savings from lower electricity consumption and the lower running costs of a smaller generator.

The other is that Eskom tariff's will not stop rising after the next three years' increases. The rise of huge emerging economies like China and India will bid up the cost of energy worldwide and it is bound to be reflected in local energy prices including electricity.

No refund from Eskom

According to all the claims made for refrigeration power saving interventions, incorporating just some of them should add up to well over the 100% mark. However, don't expect a refund from Eskom anytime soon! You won't be putting electricity back into the grid.

The fact is that you face the law of diminishing returns. A saving on a saving from multiple interventions means saving on a reducing balance – you can never get down to zero electricity usage. In practice, nowhere close to it. Also, very often, these claims are made on just a portion of a store's electricity usage. For example, just on refrigeration plant efficiency, forgetting that the cabinets also consume electricity. All this has resulted in some very disappointed store operators, who expected bigger reductions in their electricity bills for the investment they made in upgrades to their fridges and refrigeration plant.

In this article we do give estimates of power saving that different interventions can yield. Remember, these will vary with each plant configuration, the type of compressors used, the type of refrigerant used and a host of factors that affect refrigeration performance. Use them as a rough guide when you talk and plan with your refrigeration contractor. There's no magic bullet. You cannot make

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just one intervention and expect miracle results. The idea is to look at a mix of interventions that will give you the best return on your investment. If you can get a payback on the capital cost within three years, you can enjoy at least another three years of the benefit. The bad news on electricity price hikes is, in a way, the good news. Each hike makes the payback period ever shorter.

Where are you in the replacement cycle?

It is possible to keep refrigeration plants running for as long as 20 years. But what is the efficient life cycle?

You should be getting seven to ten years effective life from a refrigeration plant. Thereafter, maintenance costs from metal fatigue, plant breakdowns, corrosion and gas leaks will start to ramp up. The cost of maintaining an older system may well be double the finance charge on a highly efficient new plant with all the bells and whistles. For example, a small Pick n Pay Family Store in this situation could well be spending R30 000 a month to keep its refrigeration going. This could well be double the finance cost of Capex for a new plant at say, around R1.4 million. Access to finance may well be the problem, but at this point it is clear that a totally new plant would be better than a few piecemeal interventions to improve plant efficiency.

How much electricity can you save?

That depends on how advanced your plant is now. Refrigeration contractor, Richard Drinkow of Mainstream Refrigeration in Cape Town, completed a project last year where he converted an older multiplex refrigeration plant running on mechanical thermostatic expansion valves and fixed set point suction and condensing pressures to an updated one with the latest gear. He did this step by step, and measured the power savings achieved at each step.

The upgrade saw the installation of electronic expansion valves, a full electronic monitoring and control system which enabled floating suction and condensing and the use of variable speed fans on the condensers. as well as the installation and operation of variable speed compressors in the multiplex racks to match compressor output to the refrigeration demand from the cabinets.

Richard notes that the saving on the installation of the electronic expansion valves was nowhere near the 35% that had been traditionally claimed for them. His experience is that using all the technologies mentioned, a total power saving of 48% was achievable on the plant. ▶

Electronic expansion valves, replacing conventional mechanical thermostatic ones react instantly and precisely to changes in cabinet demand for cooling. They cut compressor power usage by around 8%. They cost little more than conventional valves and their installed cost in new cabinets may even be less as they are self-calibrating and save set-up time.

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Our colour scheme is old fashioned	We replace old shapes & colours with new
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Actual refurbs show that you can make your shelving and refrigeration cabinets look like new for around 30% of the cost of new shelving and cabinets.

- **Ice Pic will do a free assessment of your refrigerated cabinets in store on appointment.**
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With all the electronic controls and the new technologies now coming onto the market the total saving would be greater and could nudge above the 60% mark.

Going back a step, if your starting point was replacing a simplex, one cabinet / one compressor refrigeration plant with a multiplex plant, you would achieve a 15–20% reduction in power consumption. Adding all the bells and whistles described, would not yield a combined 68% power saving (20% + 48%) but something less, probably closer to a 60% total saving on refrigeration plant power consumption but perhaps 20% of a store's electricity bill – still something not to be sneezed at.

Variable speed compressor drives or variable capacity drives in the case of scroll compressors are a recent addition to the power saving interventions coming into use in South Africa. ▶

Multiplex rack controllers like these, mounted on multiplex racks, execute the monitoring units instructions.

Advanced store monitoring units like this one is a specially programmed computer that monitors and computes floating suction and condensing pressures that can save around 16% of compressor power. It can also compute and send instructions for a range of other refrigeration functions such as the timing of defrosts and it can also control non-refrigeration equipment like hot water geysers.

Add 27% more power saving

with the new Copeland EVI Scroll technology at very little or no extra cost

A simple revise of frozens refrigeration plant design and components can now save a lot of electricity. What's more, the capital cost works out at much the same – perhaps even a little less. This new technology is already working in supermarkets in South Africa.

TECHNICAL BENEFITS

This new concept in plant design cools the liquid line from the condenser. This has two principal benefits …

- It reduces the temperature of the gas leaving the compressor, which effectively reduces the amount of work needed to compress the gas. Not only does it require less power, but it needs a smaller compressor to do it.

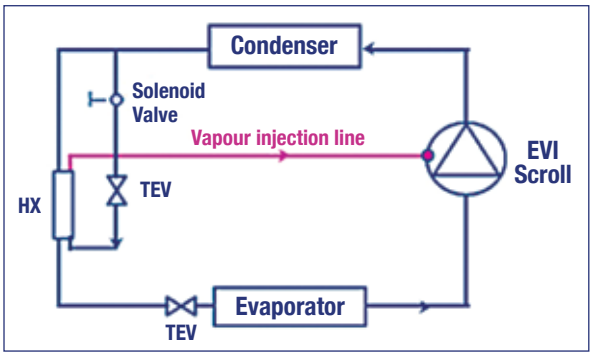
  A 10 HP compressor using Copeland EVI technology will give the same cooling power as a 14 1/2 Hp without it. This presents a considerable capital cost saving and reduces the physical size of the plant as well.
- It improves the Coefficient of Performance (COP) of the refrigeration plant. A cooler refrigerant has a much bigger cooling effect in the fridges. That means the fridges require less refrigerant to get the same cooling effect. This allows one to run smaller diameter pipes to the fridges which saves cost. In turn, this requires a smaller refrigerant charge that also saves costs.

Copeland Scroll

Copeland cools the liquid line by EVI-enhanced vapour injection of refrigerant into a heat exchanger through an electronic expansion valve. The refrigerant is tapped off the liquid line after it comes off the condenser. The resulting gas is then returned to the compressor, to cool down the compressor.

The Copeland EVI system is similar to cascading or 2-stage refrigeration systems where a separate refrigerating unit is used to cool the discharge gas of the low temperature compressor. The difference is that Copeland achieves this with a single compressor. The capacity and refrigeration gains in this system are far bigger than any increased power required to cool the refrigerant liquid from heat exchanger.

Scroll compressor rack with EVI. The heat exchanger for the rack is half the the size of a compressor and is tucked away out of sight in this picture.



HX is the heat exchanger. The diagram shows how the liquid line is tapped ahead of the heat exchanger and how the gas vapour is returned (red line) to the EVI scroll compressor. It's like a cascade system but accomplished with just one compressor.

The average net power reduction of the Copeland EVI system as measured by the European standard EN12900 Low Temp is 27%. This is compared to a conventional Copeland Scroll plant installation. Copeland offer a wide range of EVI compressor sizes from 4HP to 15HP.

Marry Copeland EVI technology to the already impressive gains of Copeland Scrolls of 25% – 30% over semi-hermetic compressors and you have a real power saving refrigeration strategy in hand.

For full information on Copeland Scroll Compressers and EVI technology contact …

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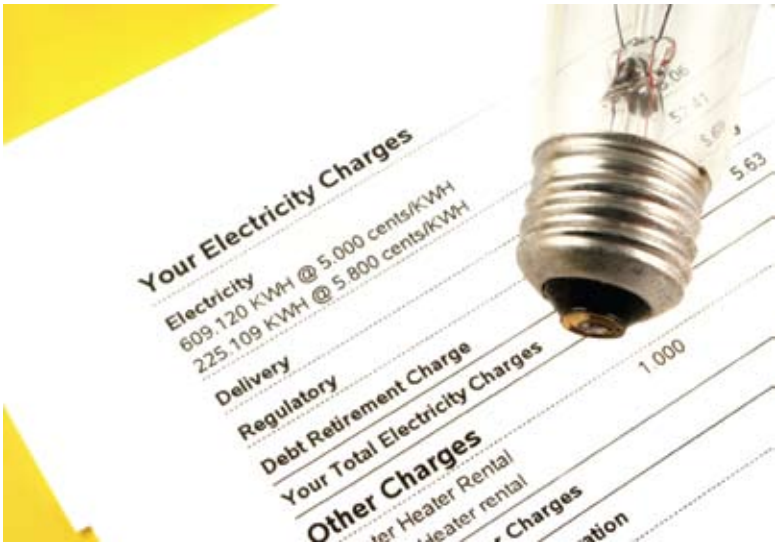
The increased electricity tariffs help make them affordable as they can add anything between 12.5% to 60% to the cost of a multiplex rack depending on compressor type and the compressor configuration in the rack.

They enable a multiplex compressor rack to almost exactly match the refrigeration output to the demand from the cabinets. This reduces energy waste and greatly reduces the number of times the various compressors in the rack stop and start in response to the changes in demand from the cabinet. When compressors start up they require an enormous draw of power to get them going. Power saving claims made for introducing variable speed compressors to a multiplex rack are in the order of 25%.

Payback on power saving interventions

Last year Metraclark, agents for Dixell and Alco electronic monitoring and control gear and expansion valves reported on the cost and the power saving involved in converting existing conventional thermostatic multiplex refrigeration systems to electronics in South Africa. This involved fitting electronic expansion valves to the cabinets, rack controllers to the multiplex units and installing a monitoring unit or store controller – the brain that does the energy saving calculations.



Electricity is now about the third biggest item on a store's profit & loss account after rent and staff costs.

The total energy saving at the trial sites for all the interventions on their medium temperature (chiller) refrigeration, viz. electronic expansion valves, floating suction and condensing and fine tuning yielded a total saving of 25.3% or 110 000 KWh a year, which at the then cost of 54c/KWh resulted in a total saving of R59 305 a year. Working on an upgrade replacement cost on existing plant of R132 000, this yielded a payback period of just over two years. The premium for this equipment in a new store compared to the non-electronic version was just R55 000 and that yielded a payback period of 11 months.

Since that time there has been huge competition among the four major suppliers of electronic refrigeration equipment and the Euro has become significantly cheaper against the Rand. This has effectively reduced the cost of the gear by around 20%. At the same time, the cost of electricity has gone up and will go up again. All this means that the payback period for advance electronic energy saving equipment has shrunk.

Also, it's interesting to note the the biggest cost item, the monitoring unit, then around R60 000, can also be used for the low temperature refrigeration which did not form part of the trial. Another important point is that it can also be used to control a lot of other refrigeration and electrical functions in the store, some of which we'll discuss later.

The ambient temperature has a huge effect on the efficiency and power consumption of compressors

Pre-cooling

There are a number of energy-saving initiatives taking place around pre-cooling either the condenser or the liquid line. The ambient temperature has a huge effect on the efficiency and power consumption of compressors. The colder winter temperatures make for lower condensing pressures which will save power even in older non-electronic compressor set-ups. Even more can be saved with electronic management and control through a valve that matches the pressure the compressors pump to, to the ambient temperature of the air flowing over the condenser to turn the gas back into liquid.

One way of doing that cheaply is using water in evaporative cooling. In this, the air flowing over the condensers is pre-cooled by an evaporative cooler. Shoprite is reported to be trialing such a system in Uppington and Pick n Pay on the West Rand. Uppington is ideal in that it is one of the driest parts of the country and evaporative cooling works best in dry areas. Evaporative cooling can drop the condensing temperature by 10–20˚C , which in a place like Uppington with ambient air temperatures often in the 40s is a huge advantage. For every 1˚C drop in the condensing temperature there is an approximate 2% saving in power used. Evaporative pre-cooling will add 1–2% to the value of the contract.

There are a number of disadvantages that need to be taken into account. First you need good quality water and the evaporative cooler still needs maintenance. Water also costs money, but even more important is the security of supply. According to climate change experts, water is going to be in scarce supply in many parts of South Africa. Then there is the question of crumbling municipal infrastructure which sees water cut off more and more often. Water can be stored in tanks on the premises, but how long might you be cut-off? One contractor recalls a prolonged water cut to one store that used water cooling on the roof that resulted in requent top ups by the fire department. Finally, evaporative water cooling will not work in humid areas, such as along the KZN coast.

A rather different approach to using cooling to improve refrigeration performance is now being trialled in two stores in South Africa. Known as Electronic Vapour Injection (EVI), this cools the liquid refrigerant line leading from the condenser through a heat exchanger that is itself cooled by tapping into the liquid line

REFRIGERATION next month ...

Energy saving at the cabinets

New frontiers: CO^2 and ammonia debut in South Africa

and returning the resulting gas back to the compressor. One would not expect to get a net gain in power reduction because it requires additional energy to cool the heat exchanger.

The way it works is to lower the condensing pressure from ten bar to two bar, which requires a lot less energy. The lower liquid temperature improves the co-efficient of performance of the refrigerant in the fridges.This requires a lot less refrigerant, which enables them to run smaller diameter pipes to and from the fridges which needs a much smaller refrigerant charge. At the same time, because less compressing power is required, the compressors can be smaller all of which also saves costs. The net power saving claimed for the system is in the order of 27%. This is one to watch because the power saving gain comes at no extra capital cost. The savings in compressor size, tubing diameter and refrigerant charge compensate for the cost of the heat exchanger and the premium on the compressor.

There's one more thing going forward that may be worse than an erratic electricity supply ... and that is no supply

When you are power starved

More and more new stores are going to face a power problem. They'll be connected at a price. That price is a restricted maximum demand draw over peak periods far below their operating requirements.

The threat by Eskom to force all existing users to reduce their power consumption by 20% may also put many more stores into a similar position. Fortunately there's something that can be done about both these scenarios. Savemoor Cash & Carry wholesaler in Tembisa is a case in point and illustrates how electronic technology can come to the rescue. It applied for 1600 Amps for the complex of which 950 Amps was required for the store. And it got; it except at peak periods between 5 and 8 in the mornings and evenings when its maximum demand was restricted to 600 Amps.

The cost of exceeding this maximum draw is not just the usual maximum draw penalties on the electricity bill – their electricity is instantly cut off and requires a call out to the municipality to have it reset, by which time their ice cream may well have melted. Their way of working around this problem was to install an electronic monitoring system or store controller – basically a computer programme to make all the energy saving calculations required to optimise the performance of their refrigeration and issue the resulting instructions to the refrigeration system.

The first thing that had to be done was to analyse the refrigeration power consuming tasks that could either be be shifted to non-restricted time slots, or for which power could either be reduced or switched off altogether in these restricted time slots. As the refrigeration power demand varies with, among other things, the ambient temperature and humidity, the number of times the

Efficient refrigeration has a major impact on store profits.

cold rooms doors are opened, the amount of stock in the freezer and chiller rooms and cabinets, it is sometimes easier to meet the 600 Amp maximum demand limit simply by shifting certain refrigeration tasks to open time than at other times when conditions are less favourable and refrigeration tasks have to be suppressed.

A meter attached to the store's incoming power supply continually updates the store controller on the store's usage of power and it accordingly shifts or suppresses refrigeration as required to keep the store under the maximum demand limit.

The defrost heaters in the freezer room draw 120 Amps which can easily spike the stores power usage over the 600 Amp peak period limit, so freezer room defrosts will be shifted to open time. Likewise, compressor start ups on the stores 45 HP compressors which draw 100 Amps have to be suppressed in peak periods.

Then there are several further interventions the store controller can make to keep the store under the maximum demand limit:

- The anti-sweat heaters in the glass door cabinets to prevent them misting up can be switched off under the right temperature and humidity conditions without the doors misting up.
- Cabinet fans and lights are always on but if the store is fast approaching the maximum demand limit the store controller can switch them off
- The set point of freezers can be reduced. eg the ice cream can be dropped from -32˚C to -28˚C over the peak periods. While this is slightly warmer, thermal inertia will prevent the ice cream loosing temperature over the limited maximum demand period.
- The store controller can also be used to control non refrigeration electrical functions such as switching off geysers, lights and the forklift battery chargers when critical.

Conclusion

There is no way that you can reduce energy consumption faster than its cost is rising.

Increasing electricity tariffs, though, are markedly shrinking the payback time to recoup the capital costs of power saving interventions and yield continuous savings thereafter. In some cases such as for new stores, it is possible to offset the capital costs of these power saving interventions because they enable one to deploy a smaller generator. And, any time that you have to use the generator, a smaller one costs less to run.

For stores faced with a restricted power diet, power saving interventions will be crucial for trading efficiently.