Ice cold energy

From supermarket chains to independently owned stores and even small spaza shops, refrigeration is arguably the biggest user of energy, and also the biggest load shedding headache

Energy efficiency and cost-savings are crucial in this sector, but how does a store go about achieving concrete savings in the current climate? Wayne Dedekind, SPAR Group Development Manager, is something of an expert in refrigeration systems, and here he shares his in-depth knowledge and years of experience in the industry.

> "Refrigeration can be very technical and controversial, as there is no single solution for all. It is largely a matter of what shoe fits best"
>
> Wayne Dedekind
> Spar Group Development Manager

"As far as the various refrigeration systems are concerned: simplex, multiplex, water-loop, self-contained and so on, each can be efficient in the correct application, and grossly inefficient in the wrong application."

So, without further ado, let's delve into the fascinating – and challenging – inner workings of store refrigeration.

Cabinet styles

Upright cabinets

Upright display cabinets are commonly used in the butchery, dairy, and fruit and vegetable sections of supermarkets, designed to provide high product visibility, while allowing for maximum use of the available floor area.

Dedekind says, "Although these cabinets provide excellent product display, contributing to increased sales and impulse purchases, they are not very efficient from an energy consumption point of view, due to the cascade cooling effect."

As these are usually open-faced, around 30% of the refrigerated air will cascade or 'spill' from the cabinet, causing a cold aisle effect. He explains...

"The total percentage of spilt air will differ, depending on the cabinet manufacturer and age, as well as the ambient conditions within the store."

These can include drafts from entrance doors, air-conditioner vents, and in-store traffic flow.

This has resulted in a move towards placing doors on upright cabinets.

Emerson ZX condensing unit for refrigeration applications

In 2009, Metraclark introduced the first Emerson ZX Condensing Unit into the South African market, which is now considered to be the first choice for cold chain businesses. Metraclark offers the complete ZX condensing units range from Emerson, designed for medium and low temperature applications with options for digital modulation of capacities.

ZX Platform Refrigeration Condensing Unit offers capacities between 2HP and 20HP, for both Medium and Low temperature applications, with Digital capacity modulation offered across the range.

The ZX range is designed on three factors demanded by industry users:

Intelligent Store Solutions: Most innovative approach to enterprise facility management. Emerson's Intelligent Store™ architecture integrates hardware and services to provide Cold Chain Businesses a single view into their entire network of facilities and understanding what facilities actually cost to operate and maintain.

The Intelligent Application architecture transforms data from application equipment and control into actionable insights. Designed to deliver value in both new and existing refrigerated applications:

- Make better decisions on recourses investments for maximum impact
- Receive accurate feedback and service customised to meet customer specific needs
- Reduce operational costs and boost profitability

Energy efficiency: Utilizing Copeland™ scroll compressor technology, variable speed fan motor, large capacity condenser coil and advanced control algorithms, energy consumption is significantly reduced. End-users can save more than 20% on annual energy costs compared to using competitor units.

Reliability: Combining the proven reliability of Copeland™ scroll compressors with an advanced electronic control system and diagnostics, equipment reliability is greatly enhanced. Fault code alerts and fault code retrieval capabilities provide information to help improve speed and accuracy of system diagnostics. Integrated electronic controls provide protection against over-current, overheating, incorrect phase rotation, compressor cycling, high pressure resets and low pressure cut-outs. It can also send out a warning message to the operator when there is 'liquid flood back', which can prevent critical damage to the unit.

Intelligent Application Control → Better decision-making
Highest efficiency → Lower energy bills
Reliability → Lower maintenance cost

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Dedekind explains: "In stores that have converted to doored cabinets, we have seen improvements of up to 30% in cabinet energy efficiencies, while the improved temperature stability of the cabinets has also reduced the cabinet defrost cycle requirements. This in turn has had a positive effect on the shelf life of the display product."

Island freezers

Island or chest style freezers use a large amount of floor area for the quantity of product variants they display, but they are able to be packed deeper than shelved upright freezers, making them excellent for stores that require large quantities of product to be displayed due to a higher volume of shoppers.

These types of freezer units are also preferred by lower LSM shoppers and SME (small to medium enterprise) markets due to their deeper freeze effect. Upright cabinets lose more cold air if they are opened and closed more frequently than chest units, meaning the product may only be in the -8°C to -10°C range. Cold air can't rise to escape out of an island or chest cabinet and products are therefore kept closer to the -18°C to -21°C range.

Dedekind says, "The most efficient island freezers are those with glass closed tops, and we are seeing a massive drive towards the R290 self-contained units currently being imported into South Africa. These units use small DC compressors, and combined with the performance of R290 (propane) as a refrigerant, they are incredibly energy efficient."

"Island or chest style freezers use a large amount of floor area for the amount of product variants they display, but they are able to be packed deeper than shelved upright freezers"

High-low display cabinets

Combination or high-low display cabinets combine a vertical cabinet with an island cabinet. These are useful in small stores where space is at a premium, as they allow for vertical product displays, as well as bulkier product storage in the bin below. According to Dedekind, the closed door gives them good energy efficiency, and although they are mainly used for frozen products, they are also suitable for chilled products. Although often more expensive than upright or island units, their functionality and effective use of the sales floor area make them especially useful for small-footprint stores.

Low and deli display cabinets

Low and deli display cabinets are mainly used to merchandise open cooked foods, processed meats, unpackaged cheese, and confectionery products. These units are designed with a customer-facing curved or flat glass barrier, allowing full visibility of the product without the potential for contact contamination. Energy efficiency depends largely on the manufacturer of the cabinet, but they do offer comparable efficiencies to most upright display cabinets. Dedekind explains that for the display of fresh unpackaged meat, cheese or ready to eat products, these are highly recommended.

Dalucon Refrigeration Products SA (Pty) Ltd, are manufacturers of high pressure polyurethane injected insulated panels, using the best European machine capabilities. Dalucon has the biggest PU insulated panel facility available in South Africa, boasting the longest PU machine, capable of manufacturing panels up to 16.5 metres long, with no joints. Panel thickness ranges from 40mm to 200mm, servicing various industry requirements. Dalucon's four high volume machines are capable of making (in excess of) 100 000m² per month.

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Open... or closed?

Closed cabinets are undeniably more energy efficient, a fact which has been accepted globally. At the recent Euroshop Expo in Dusseldorf, of the nearly 300 refrigeration companies displaying more than 1 000 cabinets, only 17 cabinets were doorless. In addition to energy efficiency, closed doors increase the shelf-life of fresh produce, due to improved temperature stability. This results in a reduced need for defrost cycles to remove ice from the refrigerator coils, and a more stable temperature inside the cabinet during these cycles.

Doors can account for up to 50% of the cost of a cabinet and are sometimes seen as a barrier between customer and product.

Dedekind, however, points out that...

> “Customers are becoming much more tolerant of the inconvenience of opening a door, especially now that everyone seems to be equally focused on saving electricity.”

The latest frameless acrylic or glass doors provide a far less inhibited view of the product, but these doors are only a solution for chilled products, as frozen doors do require a more substantial airtight seal that incorporates a frame.

Stuart Riley, Sales Director, Glacier Door Systems, says glass doors done right can offer guaranteed energy savings, and a variety of other benefits, including superior insulation and heating options for high humidity environments.

"New technology also enables glass panels to be customised to fit existing cabinets, or tailored to suit each store's specific environment," he says.

Refrigerants

Environmentally speaking, natural refrigerants such as CO_2 are gaining popularity, with the latest systems providing a safer, cleaner alternative, as well as energy efficiency. These systems can be expensive to install though, even if they are the environmentally sound option.

"With the use of the energy efficient self-contained R290 freezers, we are definitely seeing a slow transition to natural refrigerants," says Dedekind. "Currently, we choose between R404a, trans-critical CO_2 and subcritical CO_2 systems, depending on retailer's budget, ambient conditions in the store, and level of maintenance service available in the area."

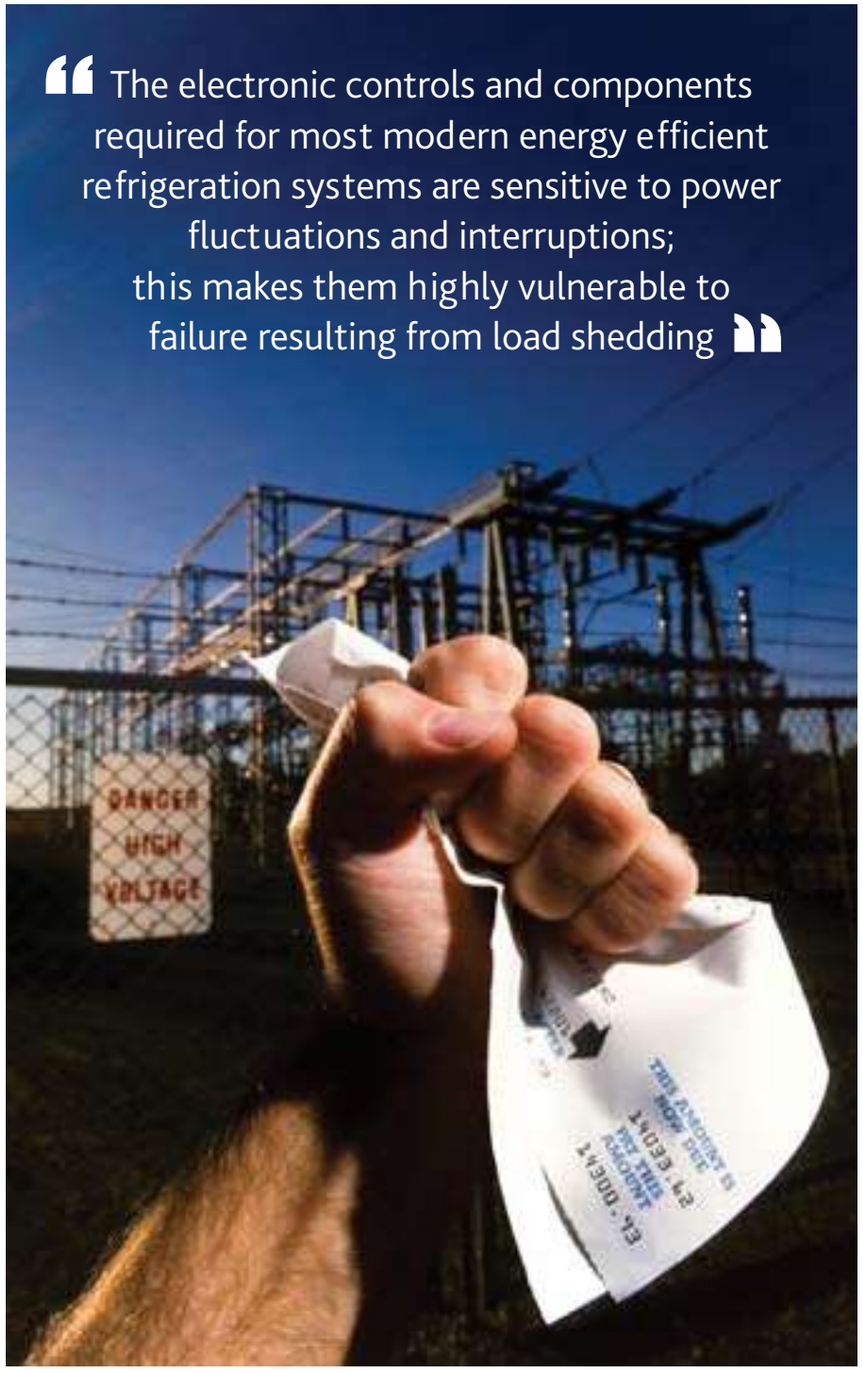
The challenge of consistent power

"Refrigeration is a great concern during load shedding, along with the general quality of our municipal electricity supplies, especially with the more advanced refrigeration systems we are using in the majority of our stores," says Dedekind.

"The electronic controls and components required for most modern energy efficient refrigeration systems are sensitive to power fluctuations and interruptions; this makes them highly vulnerable to failure resulting from load shedding. As a result, most of our installations require some sort of surge or start up protection to ensure they do not experience too much instability in the current they are receiving."

Generators are, Dedekind admits, a must for stores to keep their fridges running. Currently UPS and solar solutions that are of sufficient quality to provide enough stable power are simply too expensive.

"The electronic controls and components required for most modern energy efficient refrigeration systems are sensitive to power fluctuations and interruptions; this makes them highly vulnerable to failure resulting from load shedding"



He explains, "An average SUPERSPAR store would use 4 500kWh of electricity per day; roughly half of that would be for refrigeration. With good solar systems providing around four times their design yield (i.e. a 100kWp system would provide around 400kWh of electricity per day), a store would need at least a 550kWp system to run its refrigeration. A system this size would require around 2 500m² of solar panels, and a massive number of storage batteries if it is required to run off-grid for extended periods. This could cost upwards of R25 million and would have an ROI of more than 18 years. In comparison, a 500kVA generator would cost around R650 000, leaving around R24 million over for diesel."

Install – or refurbish?

Energy – both supply and cost – informs the answer to this question. In terms of efficiency, the latest technology and developments in systems and equipment mean that cost-savings will almost always outweigh capital investment.

It is for this reason that Dedekind says, "I am always first to advise replacing rather than refurbishing." He goes on to add: "A modern system would save up to 50% of a store's refrigeration running costs, or roughly 25% of the store's total electricity expenditure. In most cases, our stores have electricity bills in excess of R200 000

CASE CLOSED

Energy Saving Solutions

Glacier Door Systems has introduced the Air Shield ('Close the Case') Glass Door retrofit solution for refrigerated supermarket display cases, as well as the Eco Leaf Replacement Glass Door for existing glass door freezer rooms and glass door freezer display cabinets. Both solutions guarantee energy-savings in an ever-increasing energy cost environment. Part of the well-established Universal Industries Group, Glacier has 26 years' experience and are acknowledged industry leaders in refrigeration door technology. Innovative and forward-thinking, the company is built on cutting-edge technology, technical expertise and a customer-centric approach.

The value benefit

- High-quality locally manufactured solutions featuring the latest energy-saving technology.
- Demonstrated good pay back periods can be expected.
- Customised solutions to suit your store.
- ISO 9001 accredited factory.
- Safety toughened glass in accordance with SABS/SANS certification.
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Air Shield Glass Doors

Features and Benefits

- Double glazed glass doors with Argon gas fill for superior insulation.
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- Glass door heating option for high humidity environments.
- Glass doors available with hold open brackets and LED lighting options.
- Flex modelling means glass panels are customised to fit existing cabinets and are tailored to suit each store's specific environment.

A quick and easy energy-saving retrofit solution, Air Shield Glass Doors can be fitted to any existing open refrigeration case, saving up to 40% on energy consumption.

Note: The value proposal is based on R1.31 per kWh and 40% energy saving. These are averages based on our experience and can be validated per store.

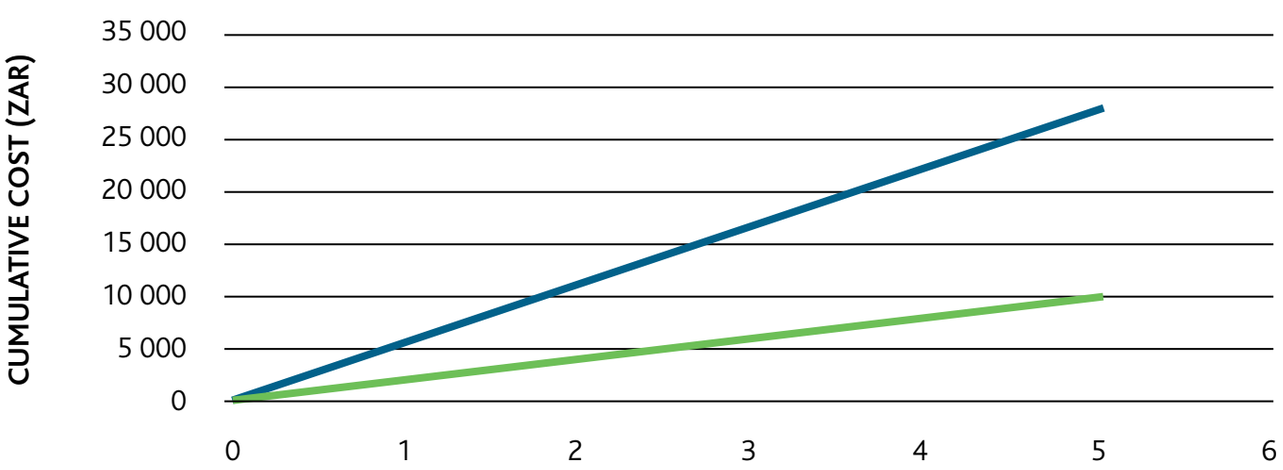
CASE CLOSED

Energy Saving Solutions

Eco Leaf Freezer Doors

Designed as a 'swop-out', energy-saving replacement glass door utilising 220V technology that eliminates the need for voltage-reducing capacitors. This results in an amperage reduction from 1.29A on the standard door to 0.46A (64%) with the replacement Eco Leaf Door.

The Eco Leaf door is 64% more efficient than the standard door. The value proposal is based on R1.31 per kWh and 64% energy saving. These are averages based on our experience and can be validated per store.



	AMPS	VOLTS	WATTS
Glacier Eco Leaf Door	0,46	230	105.8
Glacier Standard Door	1,29	230	296.7

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a month, meaning they could save R50 000 a month or more by installing new energy efficient systems and cabinetry. The advantage is that the savings continue for the lifetime of the system, well after the ROI has been achieved."

In the event that investing in a new system is just not possible, Daniel De Beer, regional manager for Sub-Saharan Africa, Emerson Commercial & Residential Solutions, says, "The cheapest energy saving solution is recommissioning, followed by everyday solutions such as floating head pressure control, floating suction pressure control, suction pressure regulation, and electronics (valves and smart controls)." He goes on to add: "It's essential to invest in a reliable leak detection system (something that can offer you accuracy down to 3 PPM). This way, you can mitigate any potential leaks and damage to the environment. A site analysis carried out by a reputable service provider will enable retailers to reduce energy consumption."

De Beer also believes that proactive and regular monitoring and maintenance are vital for creating energy savings. Many small issues go unnoticed for long periods of time because they don't necessarily shut the system down, leaving the store with an "effective but inefficient" system. For example, a blocked condenser in winter may only start affecting the system overall (causing it to trip) once the weather warms up and the ambient temperature increases, meaning the system can no longer cope. This can be a costly exercise in terms of repairs, but also for energy consumption.

CHOOSING THE RIGHT SYSTEM

Spar's Dedekind shares his basic formula for working out what sort of refrigeration system a store would need. "Determine the quantity of refrigeration required. In stores requiring a small amount of refrigeration – perhaps 7 metres of upright display cabinets, a 10-door beverage chiller, some deli display cabinets and a back-up cold room (forecourt-type store) – I would look at a modern simplex type system that runs a variable speed compressor with electronic expansion."

When it comes to display freezers, his recommendation for almost every store, outside of large SUPERSPAR stores, would be self-contained R290 units. "If we think of each individual fridge/cold room as a single application, the basic guidelines would be as follows:

- <10 applications = simplex or miniplex
- 10 to 15 applications = closed water-loop self-contained
- 15 to 25 applications = closed water-loop self-contained or multiplex
- >25 applications = multiplex

With open upright cabinets, Dedekind never recommends self-contained units, unless they use a water-loop system.

"This is because the warm discharge air from the cabinet condenser unit increases the temperature of the store, placing additional strain on the air-conditioning system. The approximate energy discharge from an open upright cabinet is 12 000Btu per meter of cabinet, at a discharge temperature of up to 60°C or higher, meaning a 12-foot display cabinet would discharge over 40 000Btu of warm air into the store, enough to raise the temperature of a 1 000m² store by 1°C every hour. With 10 of these in a store, this is quite a rise in temperature. The additional load on the air-conditioning would negate any energy savings on the refrigeration."

A heat reclamation system can reduce this effect, but these systems cost money to install and require pump systems to circulate water or glycol through the exchangers, again negating the energy savings from the cabinets. Cabinet choice is also largely dependent on the customer profile. Higher LSM areas will use more deli display cabinets and chilled product displays, while lower LSM sectors may require a greater amount of island freezer allocation, with serve-over display cabinets being almost always confined to hot food sections.

ALLOCATING REFRIGERATION SPACE

There is no 'right' formula here. Cabinet style and stock will usually depend on customer demographics – for instance, a store in a business centre will have different customer needs to a store in a family-oriented neighbourhood. From a practical point of view, refrigeration cabinets tend to be placed around the perimeter of a store, mostly because this simplifies installation and piping, although of course it is often necessary to place refrigeration units in other areas as well.

"The best way to determine what sort of cabinetry a store will need, and how much space is necessary for chilled and frozen product, is to understand your customer profile, track their preferences and expenditure, and monitor your product lines," says Dedekind.

Knowing your system's baseline energy consumption, and monitoring your store's consumption consistently, is a simple way of identifying small issues and rectifying them before they become bigger, costlier problems.

"There have been a marked number of improvements and developments in equipment and technology over the past 12 years," says De Beer. These include compressor designs (e.g. transition from semi-hermetic to scroll technology); the use of modulating suction pressure; floating condensing pressure control; the adoption of electronic valve technology; the efficiency of fans, evaporator coils and condensers; heat reclaim from condensers; adaptive or smart defrosting; more efficient or natural refrigerants; doors on refrigerated cabinets; and the adoption of LED lights. "Any systems that have not yet been updated are effective but no longer efficient, and if brought up to standard in every area, can achieve energy savings of up to 40%," explains De Beer.

Future trends and new regulations

In 2018, South Africa agreed to ratify the Kigali agreement, binding the country to the phasing out of greenhouse refrigerants, and by 2024 new HCFC installations will be banned. All new systems will need to run on natural refrigerants such as R290 (propane), R600a (iso-butane), R744 (CO_2) and R717 (ammonia).

R290 and R600a are highly flammable, so their volumes are currently limited to 150 grams of refrigerant per system. Approval has been granted to increase the limit to 500 grams, but this is still to be sanctioned. These gases are therefore limited to self-contained or small simplex plant systems for now.

Ammonia is highly toxic to humans and although it is technically and environmentally a safe gas, it is unlikely to be used in supermarket environments, due to the danger it poses to humans.

> "CO_2 is leading the way as the cleanest, safest, and most easily available option, and the advancements in this technology have seen massive improvements in both costs and efficiencies."

The latest trans-critical ejector systems show efficiencies 18% better than any previous HCFC plant, according to Dedekind.

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Say yes to solar

With electricity prices rising and load shedding a reality for the foreseeable future, alternative power sources are gaining traction. Solar energy has seen slow but steady growth, particularly in South Africa. Clean and reliable, its major drawback has always been the cost associated with installing a solar system. As the technology develops and becomes more popular, the cost is dropping, but depending on your store's power needs and the size of your system, you could be looking at paying R5 million, R10 million, or even upwards of R25 million. You also need space, whether it be a nice flat roof or a large carpark, to accommodate the solar panels.

Adding to that, most solar systems are grid-tied, meaning they need the power grid to be up in order to run in parallel with it, and will not run during load shedding. The batteries that can store solar power and keep your system running are still prohibitively expensive for smaller businesses.

Alternative solar options

That said, solar can still be the answer to your power needs. You can avoid the need for a hefty capex outlay and instead pay only for the (cheaper) power produced by the system.

Rent-to-own or a power purchase agreement are both viable options. Tim Frankish, Managing Director of the SolarSaver Group, says…
"Solar electricity under a fully-funded rent-to-own contract or PPA can be anywhere from 25% to 50% cheaper than grid power during the day [in South Africa]."

This means retail centres can, depending on their electricity use and the size of their system, save anywhere from R50 000 to R100 000 on their monthly electricity bill. In the retail space, SolarSaver usually deals directly with landlords and retail centre owners, but they also count several privately owned Spar and Pick n Pay franchises and OK Foods stores amongst their clients.

Frankish says that landlords are usually amenable to installing a solar system, when they realise they and their tenants can benefit from cheaper electricity without having to pay for solar installation. "With this type of arrangement, your solar provider should maintain and repair the system, clean the panels regularly, and keep stock of parts for repair on-hand to avoid lengthy delays."

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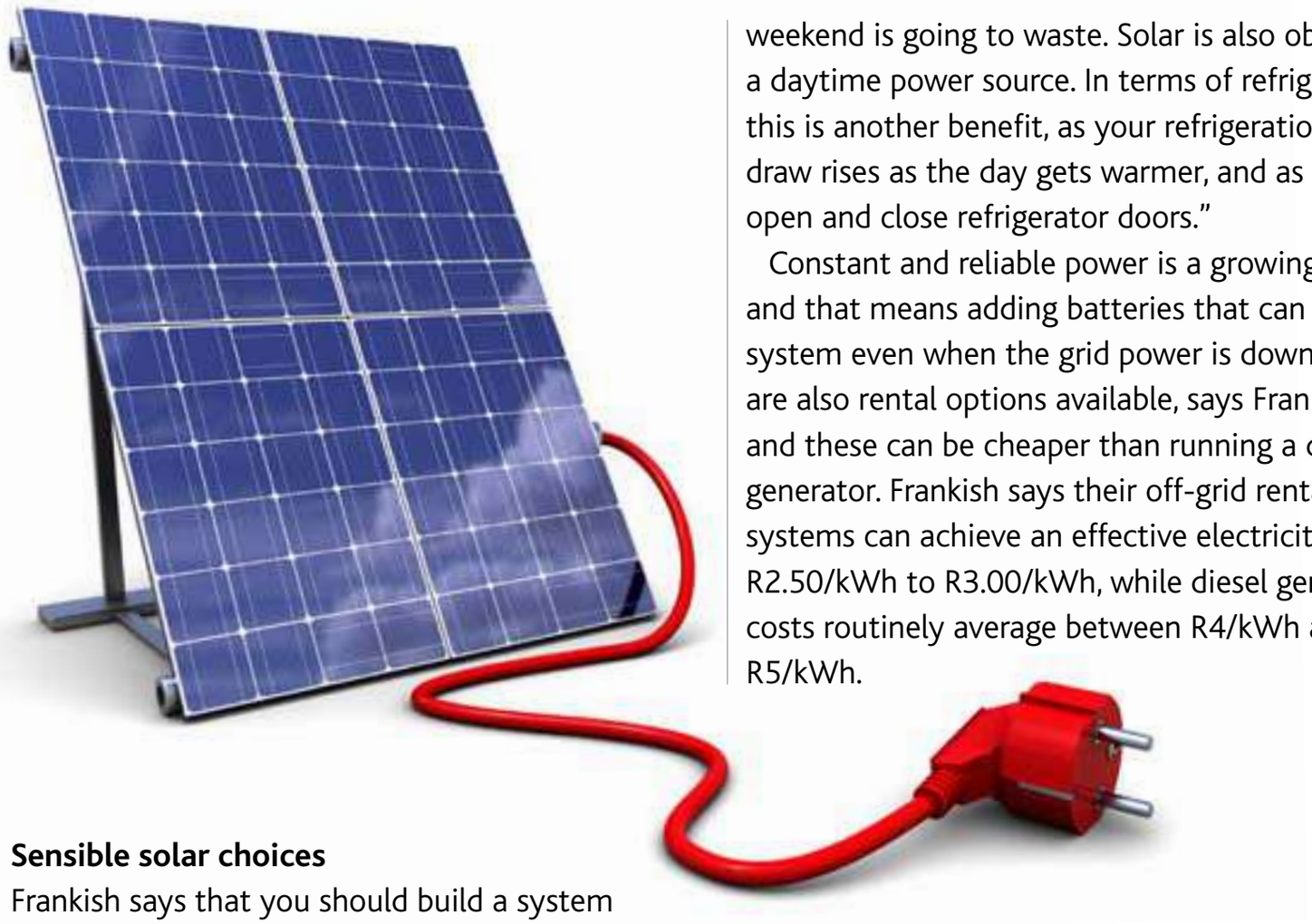

Sensible solar choices

Frankish says that you should build a system that delivers only what you need – the business rates for feeding power back into the grid are not great, if applicable (some municipalities do not allow it or simply do not pay for it at all). Look for a system that is managed and monitored by engineers 24 hours a day, and make sure you receive a report on power usage and cost-savings every month. Your service provider should also be able to advise on power usage, how best to manage the system, and where to make changes that will be of the most benefit. Frankish adds that, "Supermarkets run seven days a week, which means none of the power generated on the weekend is going to waste. Solar is also obviously a daytime power source. In terms of refrigeration, this is another benefit, as your refrigeration power draw rises as the day gets warmer, and as shoppers open and close refrigerator doors."

Constant and reliable power is a growing demand, and that means adding batteries that can run your system even when the grid power is down. There are also rental options available, says Frankish, and these can be cheaper than running a diesel generator. Frankish says their off-grid rental systems can achieve an effective electricity cost of R2.50/kWh to R3.00/kWh, while diesel generator costs routinely average between R4/kWh and R5/kWh.

Case studies

- The Valyland Centre in Fish Hoek, Cape Town, has SPAR as its major tenant and power user, and SolarSaver installed a 250kW system there in October 2018. This is a relatively small system that has saved the centre over R250 000 in aggregate electricity costs.
- Tiffany's SuperSpar in Salt Rock, KZN, was commissioned in May 2020. The site has a 350kW system that is forecast to achieve average savings in excess of R30 000 per month, despite the poor solar yields achievable at the coast relative to inland.

The future of solar

"Solar is cheaper, cleaner, secure, and not subject to big annual price increases," says Frankish.

> "Solar energy makes sense, particularly in the current economic climate. While it's a struggle to control revenue currently, you can at least use solar to help control your operating costs to a certain degree."
>
> Tim Frankish
> Managing Director, SolarSaver Group

Current regulations permit users to install a solar system with a capacity of up to 1MW without requiring an energy generation license from NERSA (National Energy Regulator of South Africa). There is a push to increase this limit to 10MW, but it is anybody's guess when or even if this will come to fruition.

Focus on the priorities

In the current climate, energy savings are critical in terms of both cost and resources. With recent developments in equipment and technology, achieving cost and usage efficiencies may take some effort, but they are more than achievable. Industry experts agree that continual monitoring and maintenance are key, along with making the right decisions in terms of cabinetry, refrigerants, and cooling systems. With solar making inroads into the South African market, there are now even more options for supermarkets and retailers looking to make effective and lasting changes to their energy consumption. **SR**