# Design changes that reduce refrigerant charge

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Soaring refrigerant price and uncertainties around future supply have made reducing refrigerant charge an increasing priority for air conditioning manufacturers and cold room installers alike.

However, there are several ways in which it is possible to reduce charge, without compromising performance.

The optimisation of refrigerant charge has always been a key part of designing cooling systems and balancing their efficiency, reliability, performance and cost, and refrigeration engineers are once again looking at refrigerant as a key piece of the puzzle.

The two main reasons for this are, firstly, the fact that refrigerant prices are rapidly increasing in parts of the world. This is largely driven by dwindling supplies as traditional options are being phased down under European F-Gas regulations, with the aim of reducing emissions from industry to 70 percent below 1990 levels by 2030 and decrease the EU's emissions of fluorinated greenhouse gases (F-gases) by 70 million tonnes (mt) of $CO_2$ equivalent, to 35 mt of $CO_2$ equivalent by 2030. In addition, other measures to limit the production of greenhouse gases under the Kyoto, Montreal and Kigali protocols have also had an effect.

Image courtesy of Pixabay, Pexels

"The move to reduce Global Warming Potential (GWP) has resulted in growing use of flammable alternatives. In such cases, having less refrigerant charge materially increases the number of applications where a system can legally and safely be used."

As a result, some refrigerants saw huge price increases, which can be attributed to stockpiling during the ongoing EU-wide phase-down of hydrofluorocarbons (HFCs) and the global HFC phase-down, which began in 2019.

Secondly, the move to reduce Global Warming Potential (GWP) has resulted in growing use of flammable alternatives. In such cases, having less refrigerant charge materially increases the number of applications where a system can legally and safely be used.

So, in the current climate, reducing refrigerant

Glacier Door Systems

# 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.
- Flexible installation timing to offset any customer disruption.
- Financing options available.

**You can trust a Glacier door**

## Air Shield Glass Doors

### Features and Benefits

- Double glazed glass doors with Argon gas fill for superior insulation.
- Glass durability and clarity with torsion bar for positive closing.
- 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.

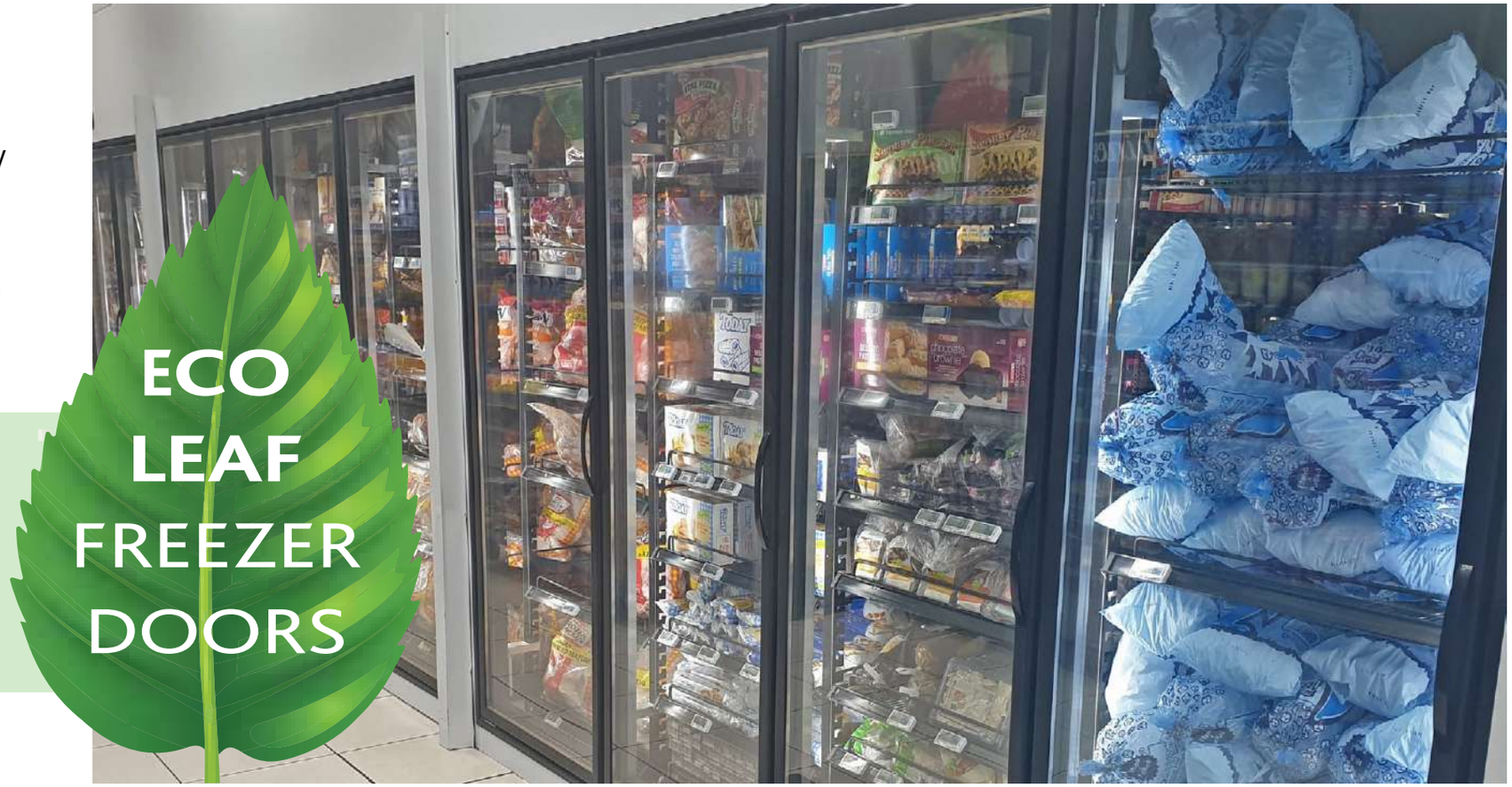
# CASE CLOSED

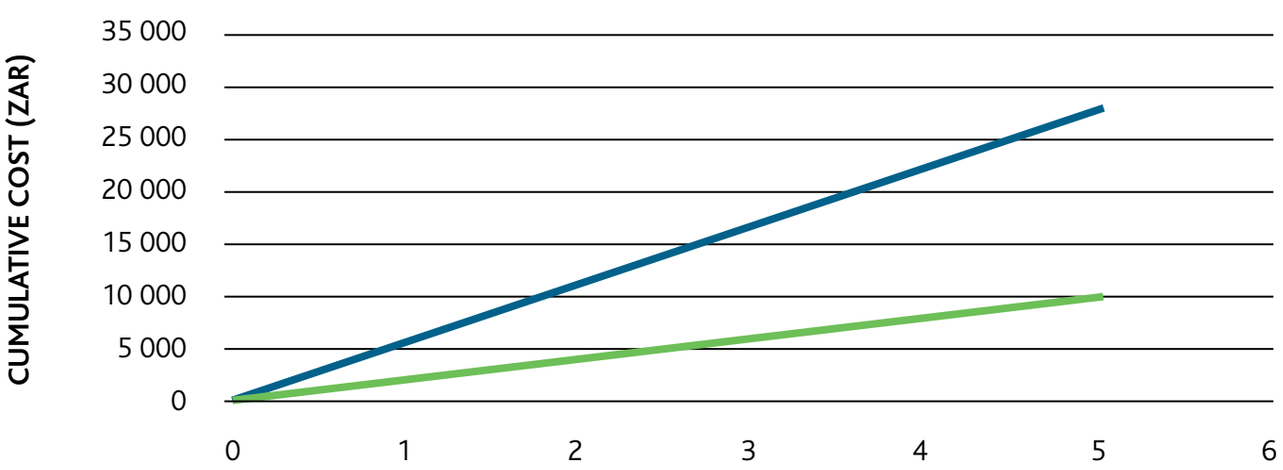
## Energy Saving Solutions

## 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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charge is a key part of gaining a competitive advantage for both manufacturers and installers, while also satisfying end users, and maintaining profitability.

## The advantages of reducing refrigerant

Supplies of traditional refrigerants are being reduced and replaced with new alternatives, but the costs of certain refrigerants are unlikely to drop in the short term.

These fluctuating costs and supplies mean that designing for lower refrigerant charge also reduces a manufacturer's exposure to risk should there be changes at short notice.

Reducing charge can also significantly improve installation flexibility. A reduced charge means A2L, A2 and A3 refrigerants can be used in a greater range of settings too, as it becomes easier to satisfy certain standards.

In addition, easier installation implies easier servicing. By making units simpler and lower in charge, servicing and maintenance can be carried out faster and more safely, further reducing total cost of ownership and offering a competitive advantage.

## Ways to reduce refrigerant charge

Reducing refrigerant charge can potentially make systems safer, more flexible and more competitive. This can be achieved in several different ways, while at the same time possibly bringing additional benefits to the system's full and part-load efficiency, or overall size.

Danfoss has identified a number of approaches that engineers can take to reduce refrigerant charge, without compromising on safety, efficiency or cost. These include:

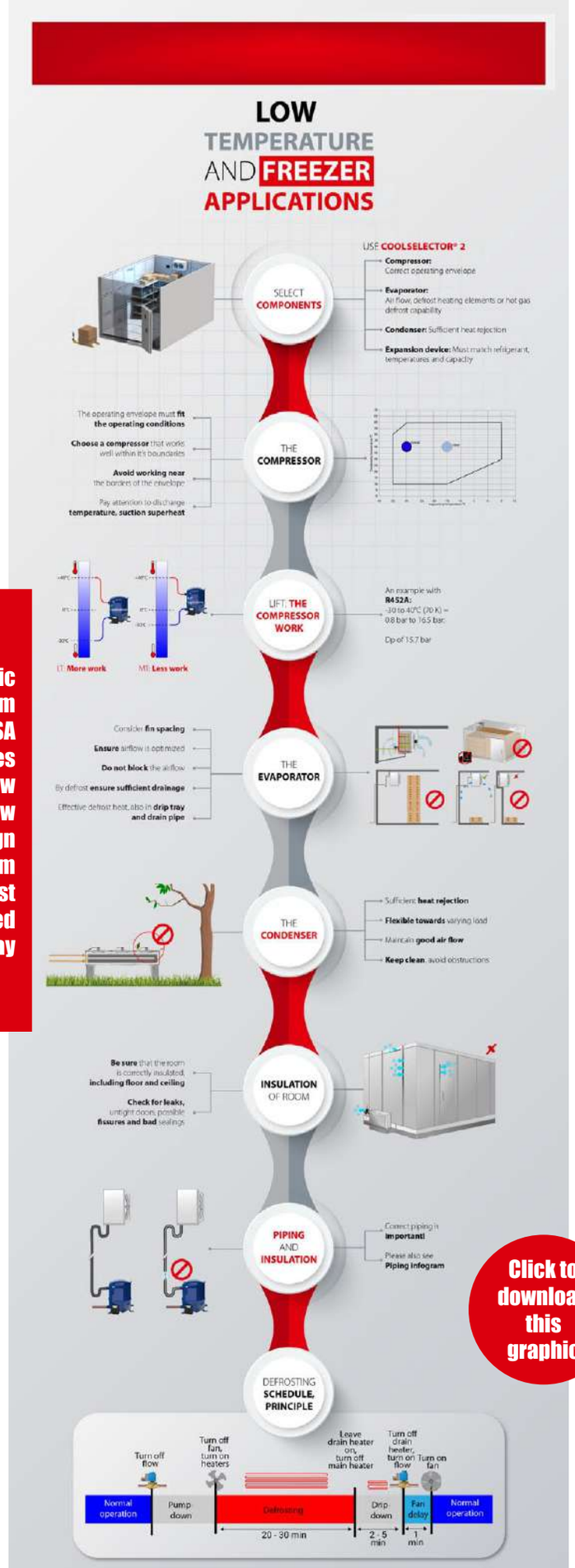
### 1. Reducing internal volume by reducing piping

Internal volume is an important factor for refrigerant charge, due to the direct correlation between the two. Internal volume is dictated by the size and number of components, meaning that minimising the length of piping – or removing it altogether – is vitally important, and the smaller diameter you can practically use, the better.

This is especially true in the liquid line. Each refrigerant has its own ratio of liquid to vapour density, but, in all cases, the liquid refrigerant density is significantly higher than vapour. So, even though most of the volume in a system might be gas, the vast majority of its mass is in the liquid phase. This means that each reduction in liquid volume has a disproportionately high impact on the overall charge amount.

A potential solution would be to move some components closer to the condenser, or design reversible heat pump systems with bi-flow expansion valves, instead of bypassing it by adding parallel piping with check valves. As long as refrigerant remains as a liquid before it reaches the expansion valve, and as long as the valve has sufficient capacity, reducing the diameter of the liquid line and the associated increase in pressure loss won't affect system performance.

**Infographic from Danfoss SA provides an overview on how to design a cold room in the most optimised way**

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# Save Energy
# Save Money

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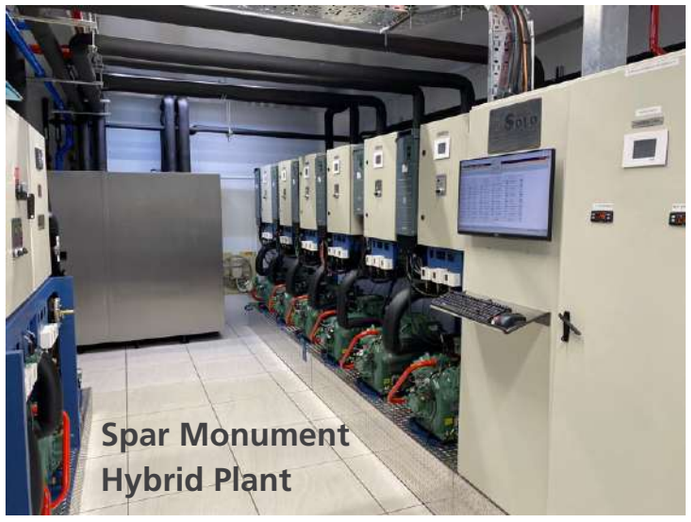

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Hybrid Plant

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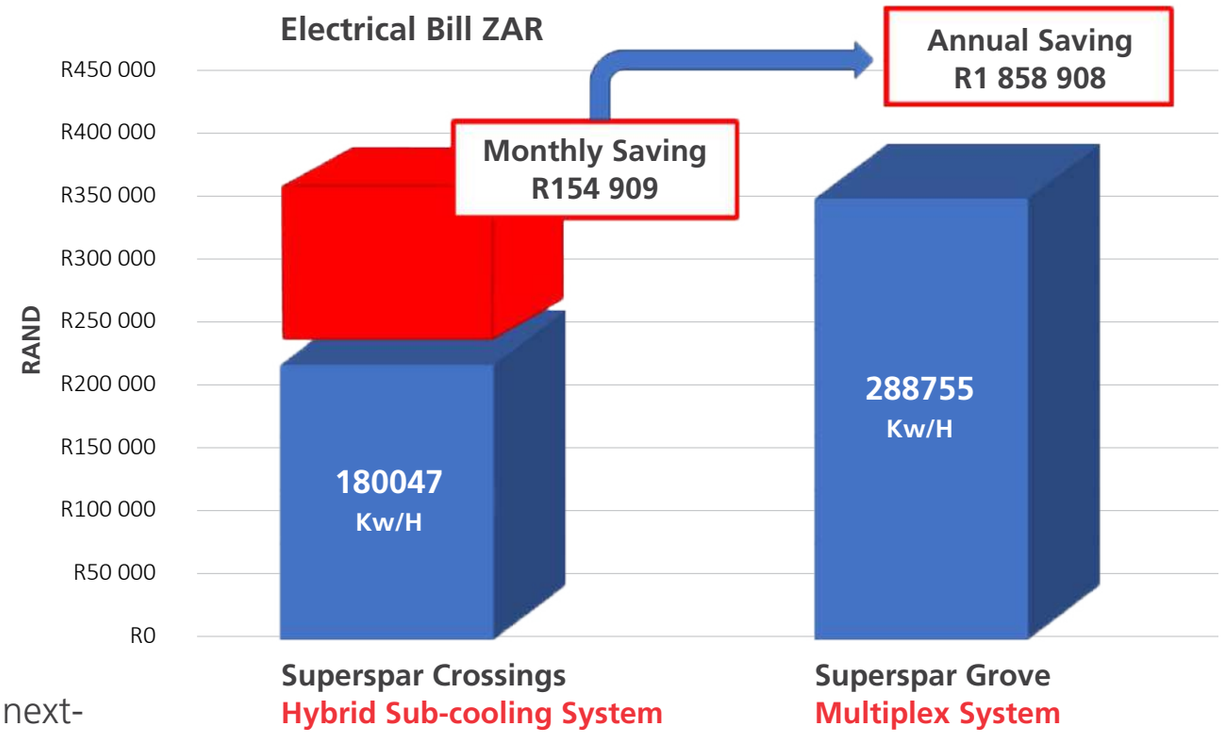


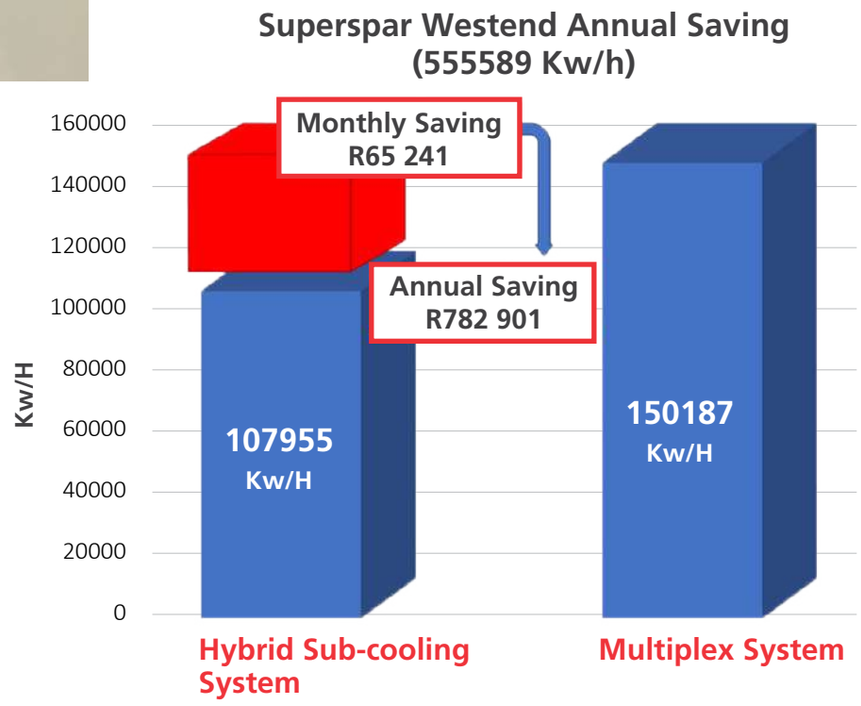


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## 2. Improving heat transfer efficiency

A high proportion of charge can be found in the heat exchangers, so their design has a significant impact on a system.

> "An efficient heat transfer process in modern plate and micro channel heat exchangers can have a positive effect on system design and can also improve system efficiency."

A micro channel heat exchanger (MCHE) uses flat tubes with small channels that not only increase heat transfer efficiency, but also reduce the internal volume and refrigerant charge by up to 70 percent compared to fin and tube heat exchangers. In applications where MCHEs aren't a viable solution, fin and tube coils with smaller diameter tubes can be used.

Heat exchangers in refrigeration systems have a two-phase mixture of liquid and vapour refrigerant. In the evaporator and condensation processes, the amount of vapour changes from the inlet to the outlet of the heat exchanger. A smart heat exchanger design minimises the volume taken up by liquid refrigerant and charge in the heat exchanger.

An asymmetric plate heat exchanger design will reduce internal volume on the refrigerant side and the amount of refrigerant in the system, without an adverse impact on waterside pressure. As a side benefit, this will result in improved heat transfer performance.

**Case controls:** Your refrigeration system is the natural place to look for energy efficiency gains. To unlock that potential, you need a controller, expansion valve, and high accuracy sensors that are smart enough to make the technology work together – and a system manager that can help you see and control the bigger picture.


**Refrigeration IoT solutions:** Through the VeBox cloud-based infrastructure, the Danfoss Prosa telemetry devices and the electronic controllers, Danfoss provides a complete telemetry & cloud solution to the food and beverage industry, for installation in various types of equipment.

**Connected food retail solutions from case to cloud:** Components designed to provide the lowest total cost of ownership, while at the same time reducing food loss and the carbon footprint of your supermarket refrigeration system.

**Highly efficient industrial refrigeration systems for the food industry:** Industrial refrigeration systems engineered to ensure perfect conditions for food in safe temperature controlled environments, while allowing for improved food safety and reduced food waste.

# We see

## access to fresh food being the global norm rather than the exception.

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### 3. Considering the system architecture

Traditional flooded evaporators require a large pool of refrigerant to work. In falling film evaporators however, refrigerant is sprayed on the tube bundle and only a small portion of the tubes are submerged in refrigerant, resulting in significant charge reductions.

In direct expansion (DX) systems, the refrigerant flows inside the tubes using flow boiling and condensation processes. DX systems will typically have less refrigerant charge than flooded systems, but will also be less efficient.

New DX heat exchanger technologies, such as micro plate heat exchangers, work with a very small temperature difference, and offer a similar performance to flooded and falling film systems.

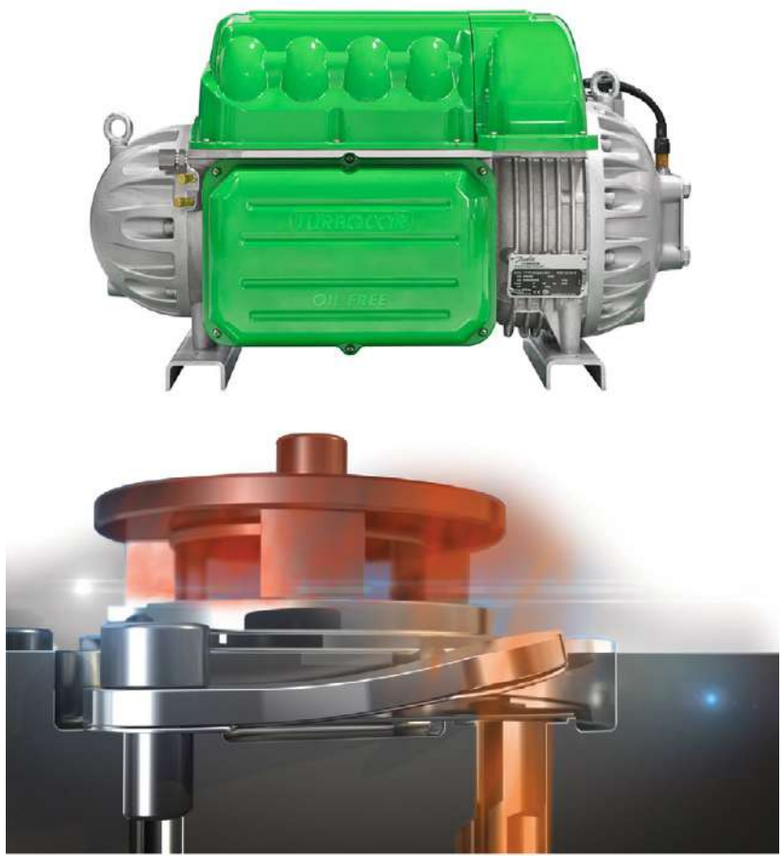
In some applications though, it isn't feasible to have a packaged solution. The evaporator and condenser sections can only be connected by long refrigerant lines, and require a significant charge.

Alternatively, a water-cooled condenser and a brine loop can be used to carry the heat from the condenser to a remote cooler, which eliminates long refrigerant pipes and will significantly reduce system charge.

### 4. Taking advantage of newer compressor technology

A system design engineer has few tools to meet ever-increasing efficiency requirements.

One method could be to use a larger heat exchanger with a smaller temperature difference. However, while this is a reliable way to increase system efficiency, it uses more refrigerant.



Innovative and efficient oil-free and IDV compressor technology minimise refrigerant charge.

High efficiency compressors can improve efficiency not just in full-load situations or applications, but also in part-loads. This is particularly true for variable speed compressors, and those which use an intermediate discharge valve to prevent over compression in part-load conditions. Using an oil-free centrifugal compressor with variable speed functionality can significantly increase compressor efficiency.

By taking advantage of newer compressor technologies, it's possible to meet efficiency requirements without increasing charge.

### 5. Deploying smart control systems

Taking better control of system conditions can give an immediate refrigerant saving.

Using an electronic expansion valve (EEV) to replace a thermal expansion valve (TXV) results in better control of superheat and more effective use of heat exchangers, especially in part-load conditions.

For example, using variable speed fan control to control head pressure, instead of a mechanical valve to flood a heat exchanger, may mean that the size of the receiver can be eliminated or, at least, reduced.

And a variable speed drive for the condenser fan motor means it can adapt to any condition and power consumption can be decreased. This is a far better way to increase part-load efficiency rather than using larger heat exchangers that use more refrigerant.

Match the solution to your specific requirements

Clearly, there is no one right answer covering all applications. But, as refrigerant prices continue to play an important role in system design decisions, and as safety continues to be an increasing concern for those using flammable refrigerants, it's likely that engineers will use a combination of methods to improve cost, efficiency and competitiveness. **SR**

Better superheat control for lower refrigerant charge.