Refrigeration Energy-Efficiency Opportunities

FOR THE AUSTRALIAN MEAT PROCESSING INDUSTRY

COMMERCIAL FREON SYSTEMS

REFRIGERATION ENERGY-EFFICIENCY OPPORTUNITIES

FOR THE AUSTRALIAN MEAT PROCESSING INDUSTRY

COMMERCIAL FREON SYSTEMS – GUIDEBOOK

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DATE PUBLISHED	30 October 2021
PUBLISHED BY	Minus40 PTY Ltd

The Australian Meat Processor Corporation acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

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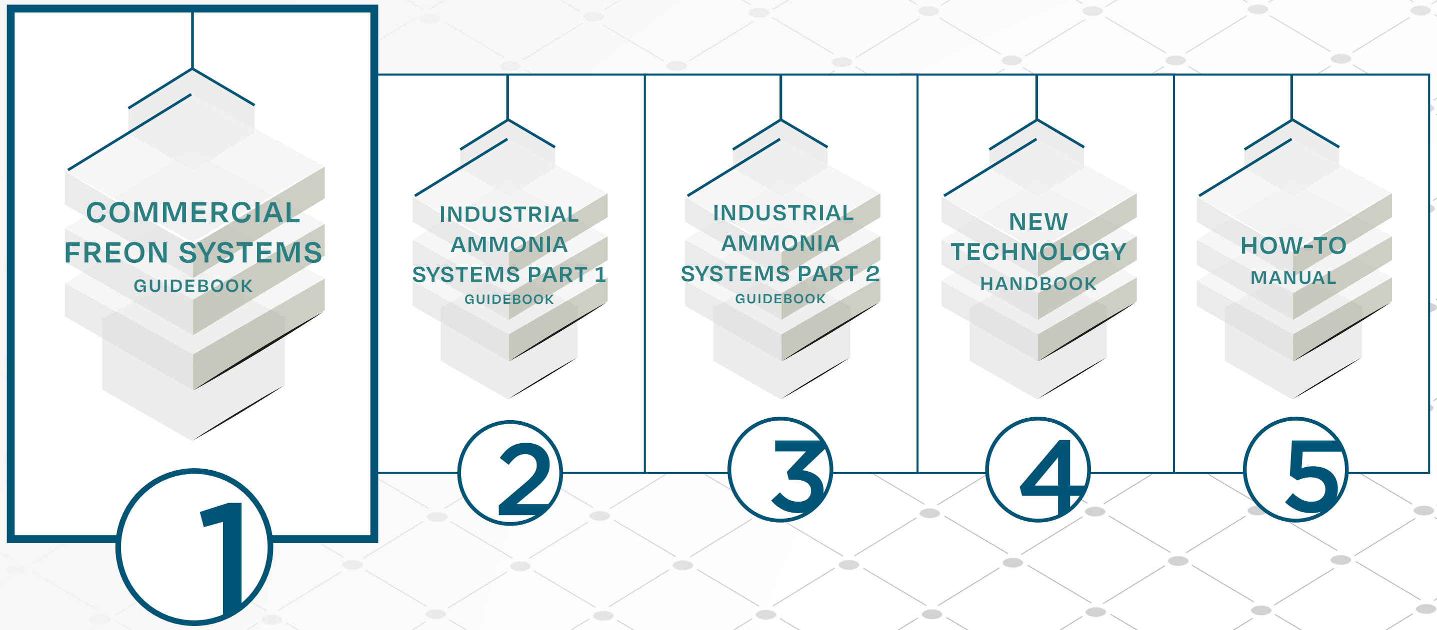
CONTENT OVERVIEW

NEW TECHNOLOGY

As freon refrigerants are being phased-out, smaller processors will have to look for alternatives. The New Technology Handbook presents a handful of market ready, future proof and energy efficient solutions for a plant upgrade.

INTRODUCTION

This Guidebook is one of 5 Guidebooks/Manuals which were developed during the **"Refrigeration Plant Energy Improvement"** research project.



Guidebook: Commercial Freon Systems covers **smaller abattoirs** which often use multiple small commercial refrigeration systems with freon refrigerants.

Guidebook: Industrial Ammonia Systems Part 1 & 2 cover **medium to large sized abattoirs** which use big, centralized ammonia systems for refrigeration. These systems are much more complex than small commercial systems and require a stepped, strategic approach to improve energy efficiency.

The New Technology Handbook covers the **most recent developments** in refrigeration as applicable to the red meat industry. Refrigeration is undergoing some decisive changes which will have major impacts on the operational costs of refrigeration systems. **Awareness of these developments** is crucial when it comes to decision-making on major plant upgrades/restorations as investments into outdated technologies could result in a competitive disadvantage.

To further **determine the viability** of opportunities discussed in the books mentioned above, the How-To Manual gives guidance on how to initially assess opportunities and use the Energy Efficiency Opportunity Calculation Tool where applicable.

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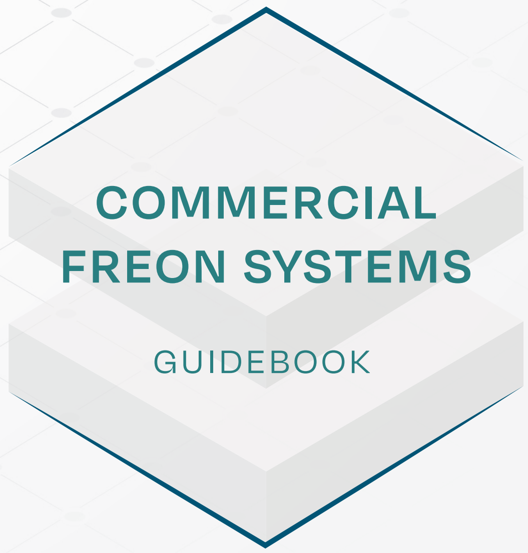
GUIDEBOOK: COMMERCIAL FREON SYSTEMS

Small meat processors often use **simple commercial refrigeration systems with synthetic (freon) refrigerant** to cover their cooling needs. These systems provide **very few commercially viable options for energy efficiency upgrades** compared to larger centralised plants. This is even more apparent when it comes to small single compressor units, because these units have a comparatively small energy use and low utilisation. This makes it almost impossible for upgrades to be financially feasible as the highest possible energy savings are small and therefore only justify a small capital investment. Commercial refrigeration systems have **short design lifespans of 10-15** years unlike industrial systems. Projects therefore have less time to recover their investment especially on existing equipment with even less remaining usable life left. Processors are advised not to invest in the improvement of older commercial refrigeration systems, but to simply replace them, preferably with new technology and not like-for-like.

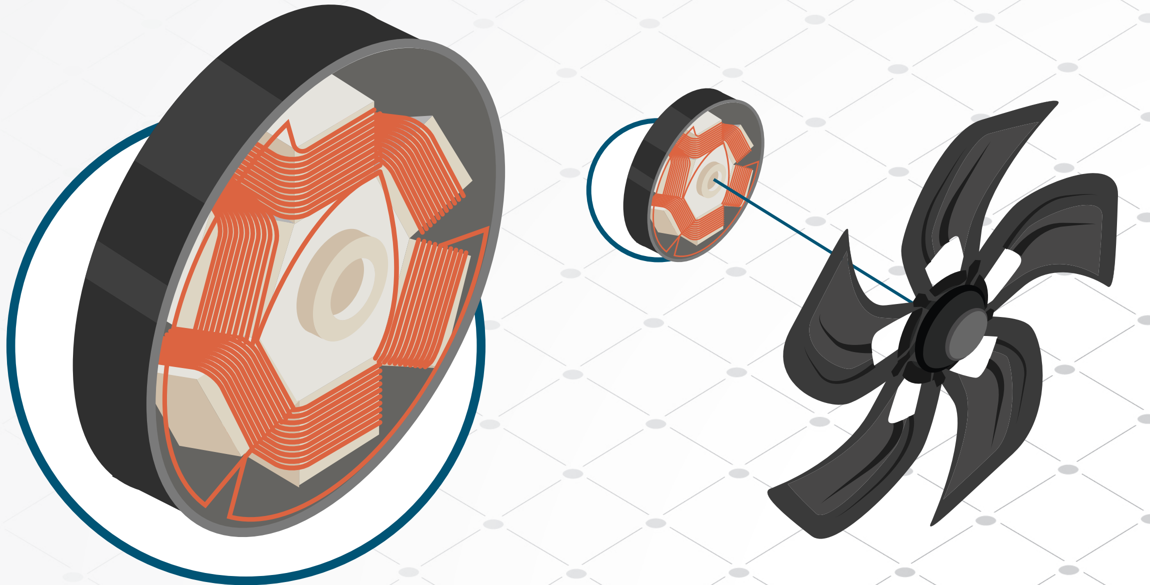
However, commercial refrigeration systems that are relatively new and in good condition may still have enough life left in them to make investments pay off. For example, compressor racks (as opposed to single compressor units) could lend themselves to such improvements. This guidebook will present some upgrade options. In other circumstances sites are advised to replace their plant. Some of the opportunities presented in this guidebook focus entirely on a plant replacement. Energy savings opportunities presented for upgrade should also be considered for a plant replacement as a new plant could make use of them as well. In fact, they become more feasible as they are merely a surcharge on equipment which must be purchased anyway. This is especially true for possible hardware replacements such as evaporators and condensers.

Another **caveat concerning freon systems**, maybe the most important one: Due to the disproportionately **high global warming potential** of freon refrigerants they are currently being phased out by Australia and around the world. Apart from efforts made by the Australian meat processing industry towards becoming more sustainable, these refrigerants will become more expensive in future. From a perspective of total lifetime costs synthetic refrigerant systems are **not an attractive option going forward.**

The **New Technology Handbook** which is part of the series of guidebooks offers a wide range of possible replacement technologies which could be used to replace synthetic refrigerant systems.

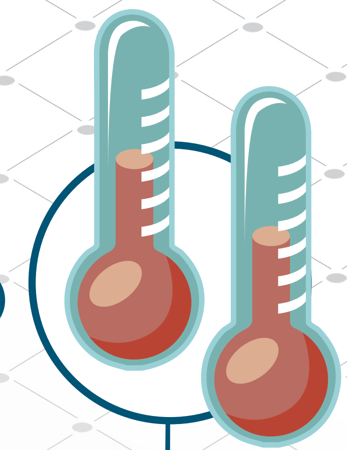


TERMINOLOGY



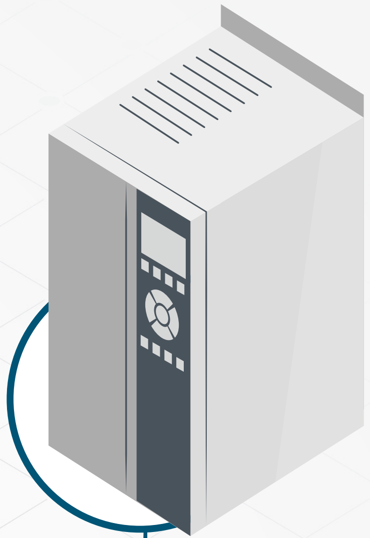
1 EC-MOTOR/FAN

EC stands for **E**lectronically **C**ommutated. These motors possess a controller which commutates the electric current in such a way that it can vary the speed of the motor. As for VSDs this allows for speed control and its benefits.



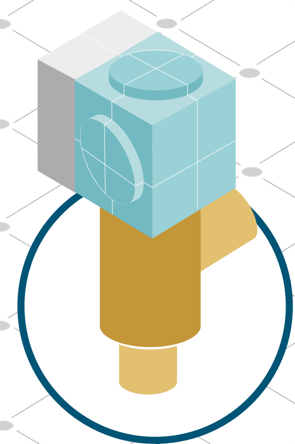
KELVIN [K] 2

Scientific unit for absolute temperature and temperature differences. E.g. the difference between 30 °C and 20 °C is **10 K.**



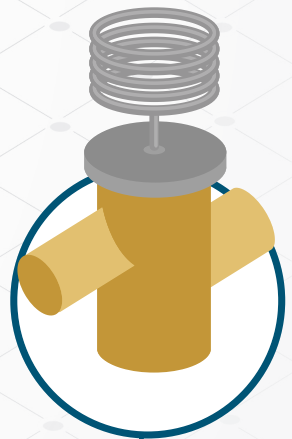
VSD 4

Varible **S**peed **D**rive (sometimes refered to as VFD, AFD and others) is the broad term used for power electronic controllers that allow you to run AC-motors as commonly used in refrigeration at varying speeds. This allows for **speed control** which brings many benefits.



5 EXV

Electronic **E**xpansion **V**alves are valves that are actuated by electro-mechanical means.

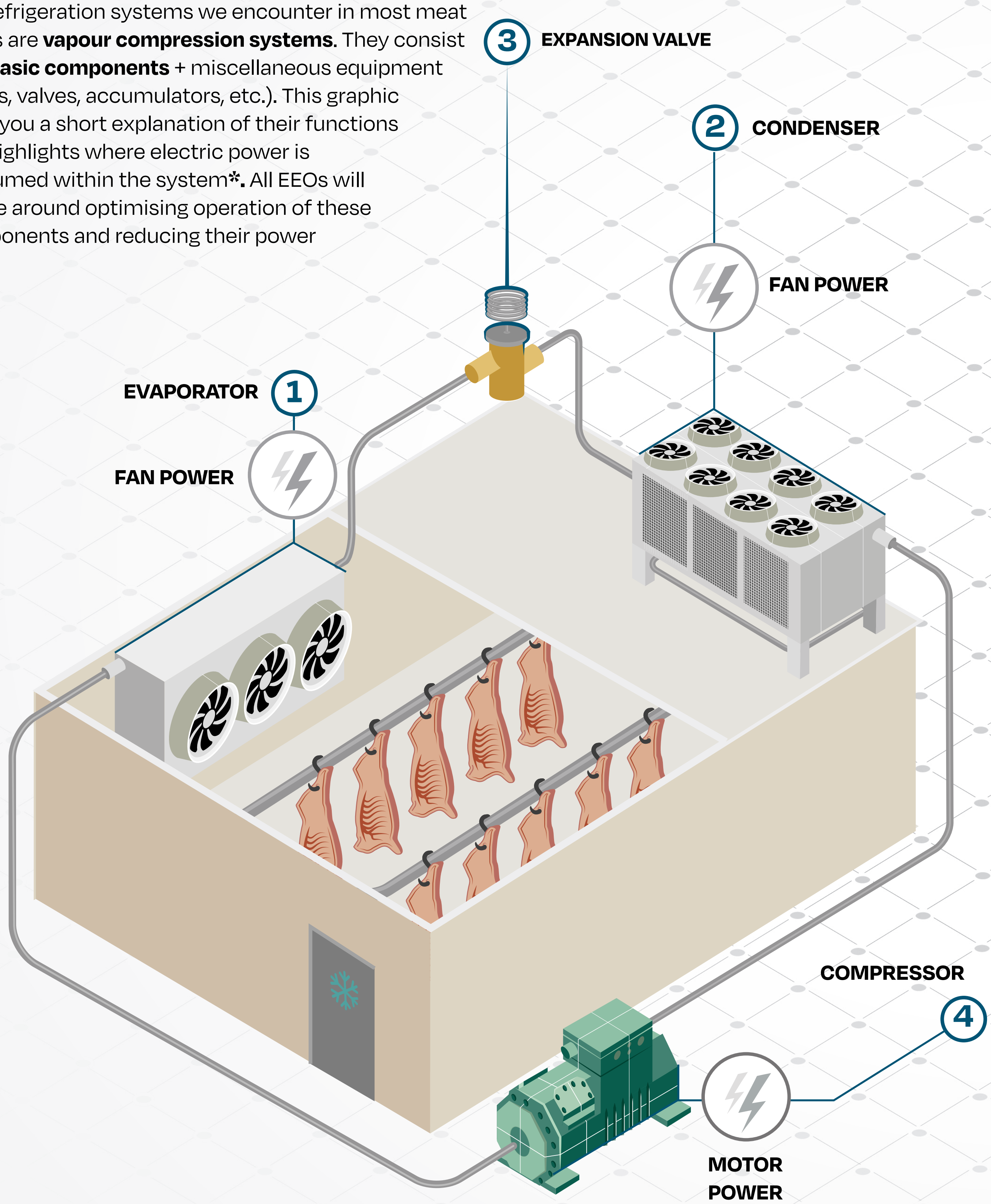


TXV 6

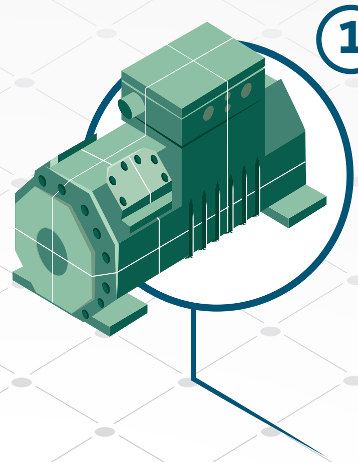
Thermostatic Expansion Valves are purley mechanically driven.

REFRIGERATION BASICS

The refrigeration systems we encounter in most meat works are **vapour compression systems**. They consist of **4 basic components** + miscellaneous equipment (filters, valves, accumulators, etc.). This graphic gives you a short explanation of their functions and highlights where electric power is consumed within the system*****. All EEOs will evolve around optimising operation of these components and reducing their power draw.



*There are other power consumers like electronics, controls, etc. But these are of less concern.



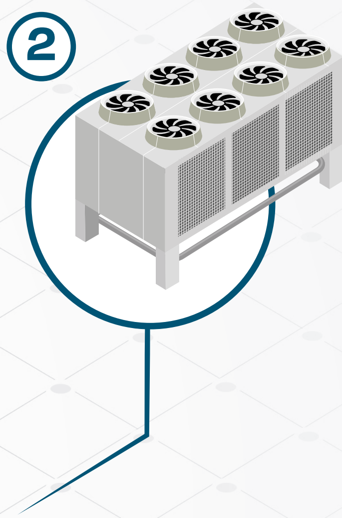
1 COMPRESSOR

Takes in cold vapour coming from the evaporator and expansion valve at **suction pressure.** Compresses it to hot gas at **discharge pressure** using electric power.

▼

Biggest power demand in the system. The higher the pressure difference between suction & discharge, the more power is needed. E.g. it takes more energy to compress vapour from a **colder** evaporator (pressure is **lower**) or to discharge into a **warmer** condenser (pressure is **higher**).

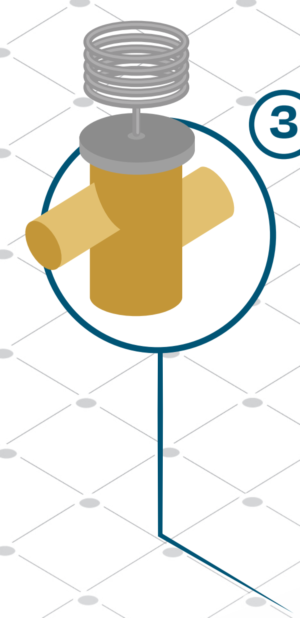
CONDENSER 2



Refrigerant **rejects heat** to ambient. Most of the heat is rejected by turning from vapour to liquid at **condensing pressure.** For practical purposes condensing and compressor discharge pressure are the same. This is also commonly referred to as head pressure. Capacity depends on temperature difference to ambient, air flow and heat exchanging surface.

▼

If **ambient temperature rises** and the condenser is already at full capacity, the condensing pressure rises and with it **compressor power**.



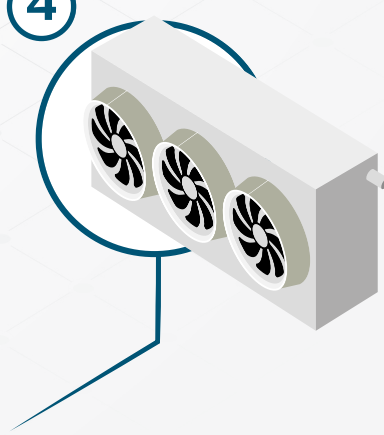
3 EXPANSION VALVE

Creates a **large pressure drop** between high and low pressure side by restricting refrigerant flow. After the valve, part of the refrigerant flashes into vapour cooling the remaining liquid to lower temperature.

▼

The valve itself does not consume power, but **flash gas generation** from the valve requires **compressor power** for subsequent re-compression.

EVAPORATOR 4



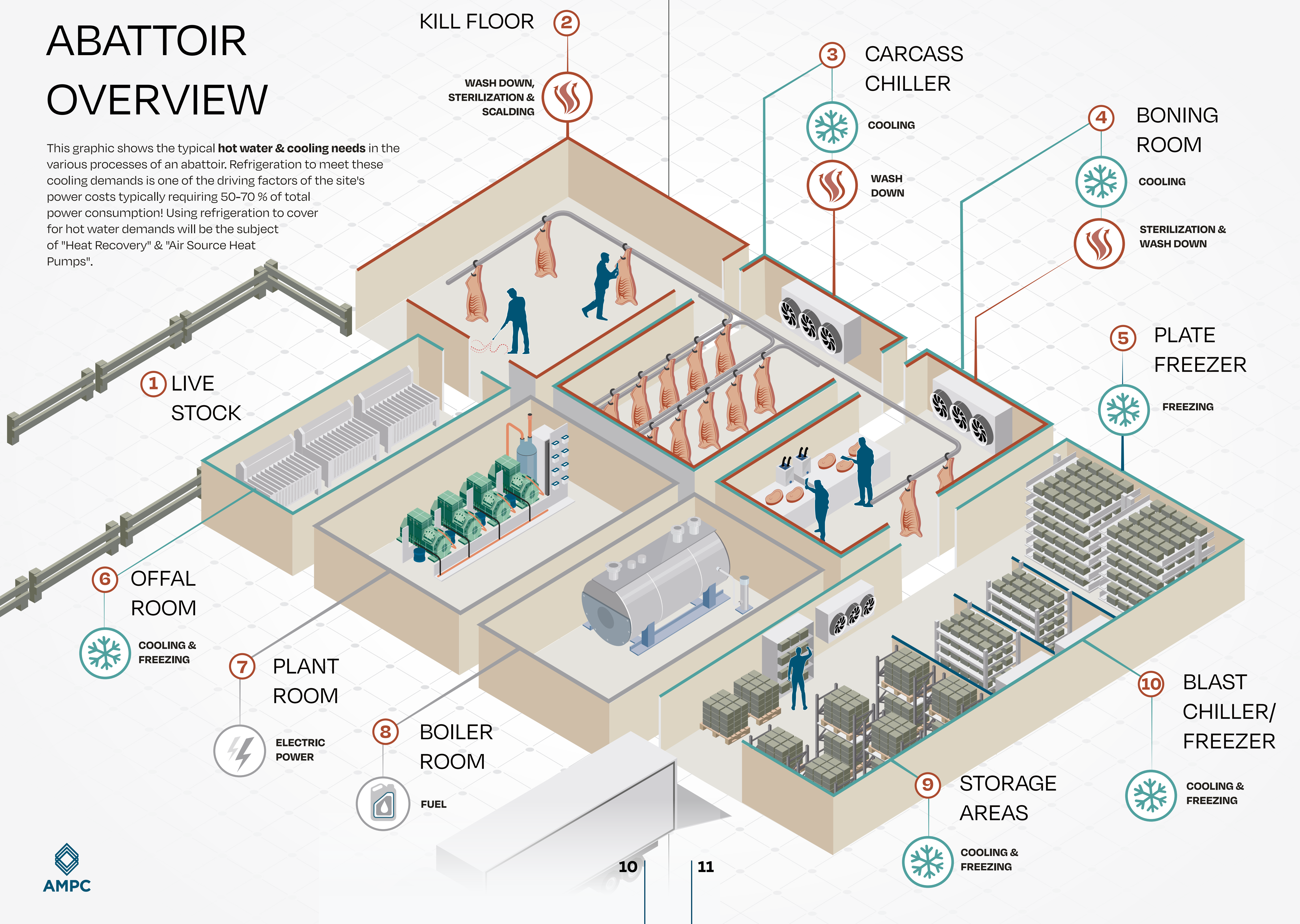
Refrigerant **absorbs heat** by evaporating from liquid to vapour at **evaporation pressure**. For practical purposes evaporation pressure and suction pressure are the same.

▼

To reach **colder temperatures** evaporation pressure must be lowered, in turn **compressor power** rises.

ABATTOIR OVERVIEW

This graphic shows the typical **hot water & cooling needs** in the various processes of an abattoir. Refrigeration to meet these cooling demands is one of the driving factors of the site's power costs typically requiring 50-70 % of total power consumption! Using refrigeration to cover for hot water demands will be the subject of "Heat Recovery" & "Air Source Heat Pumps".



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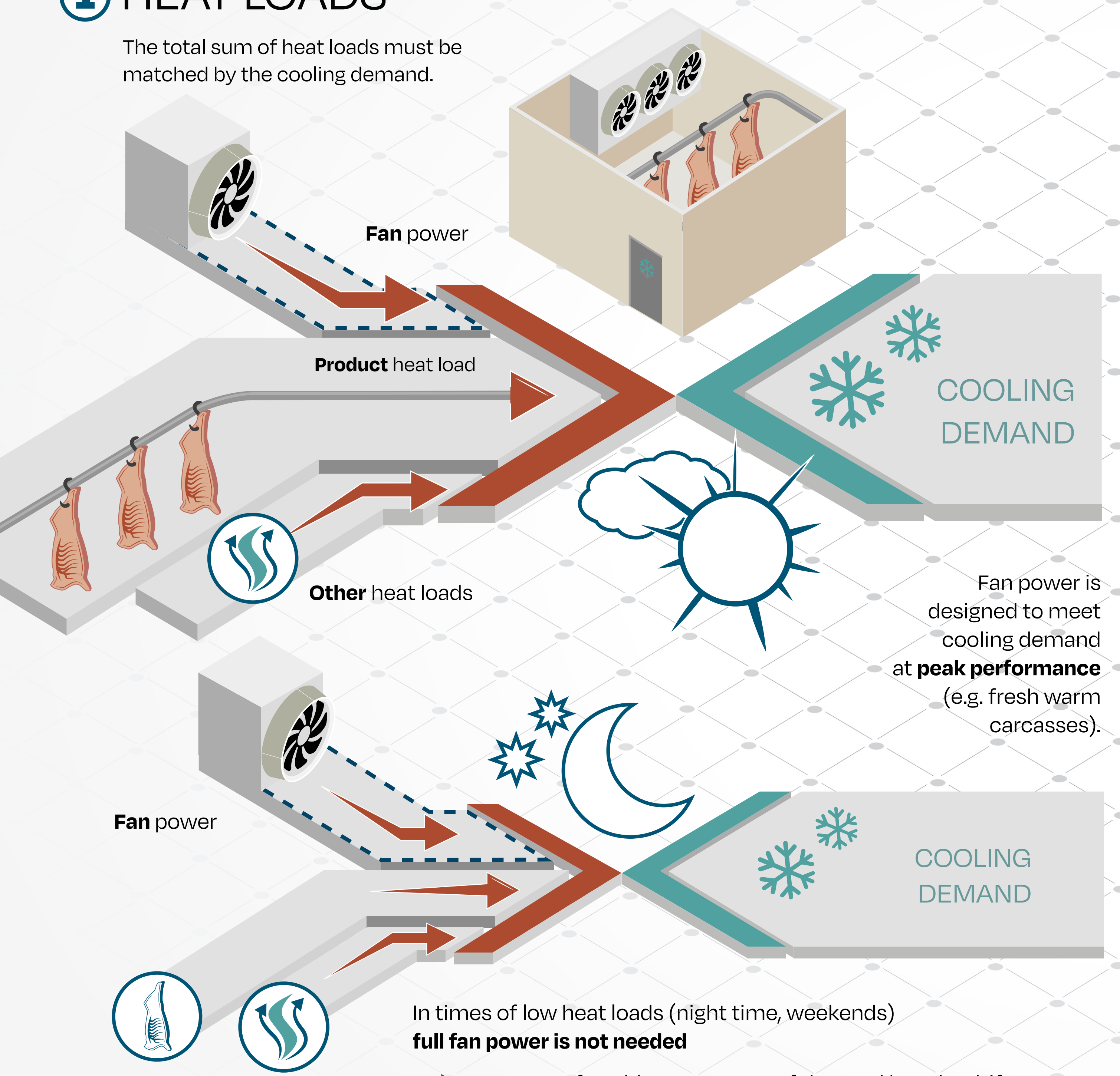
EVAPORATOR FAN SPEED CONTROL

& REPLACEMENT

① HEAT LOADS

The total sum of heat loads must be matched by the cooling demand.



In times of low heat loads (night time, weekends) **full fan power is not needed**

- Accounts for a big percentage of the total heat load, if left running at **full capacity.**
- **You pay twice.** First to **power the fans**, later to **remove fan power** by means of cooling.

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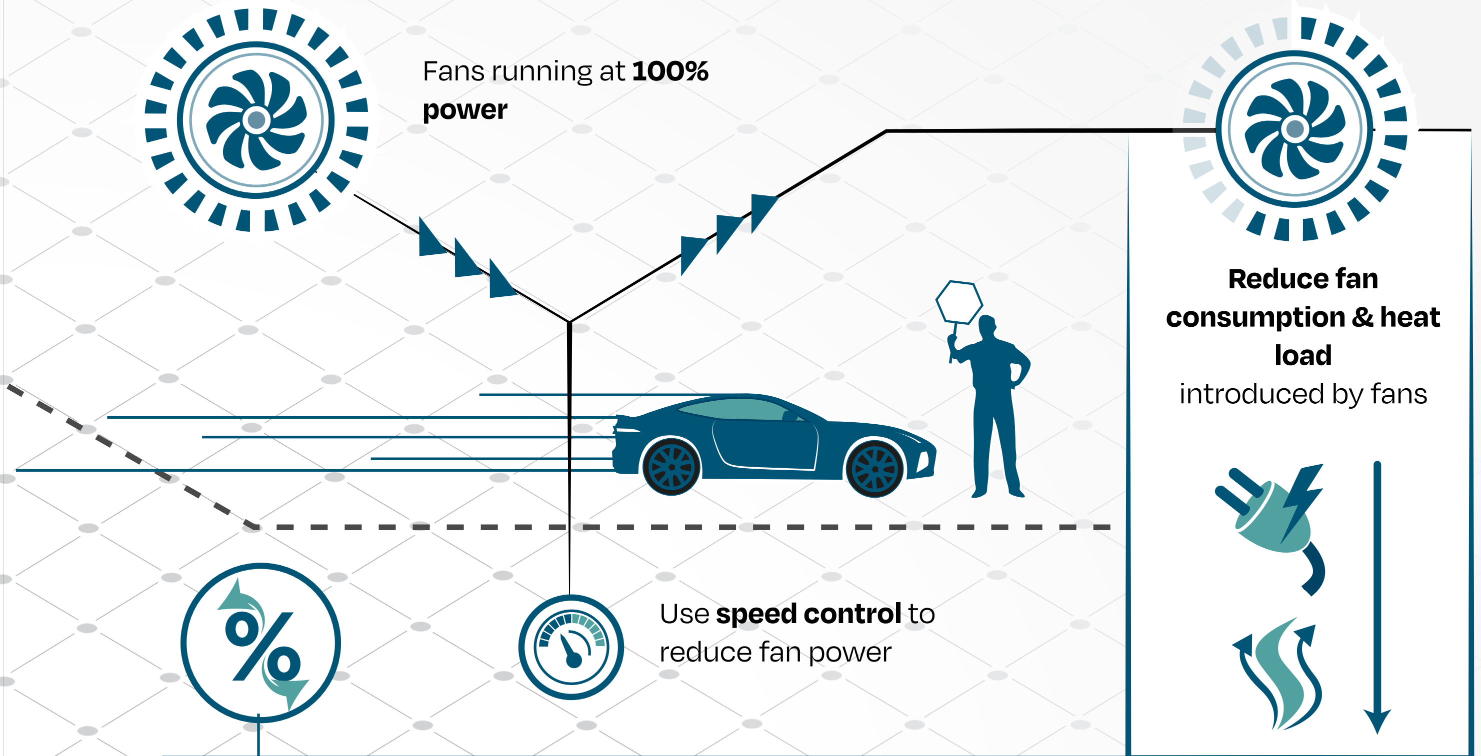
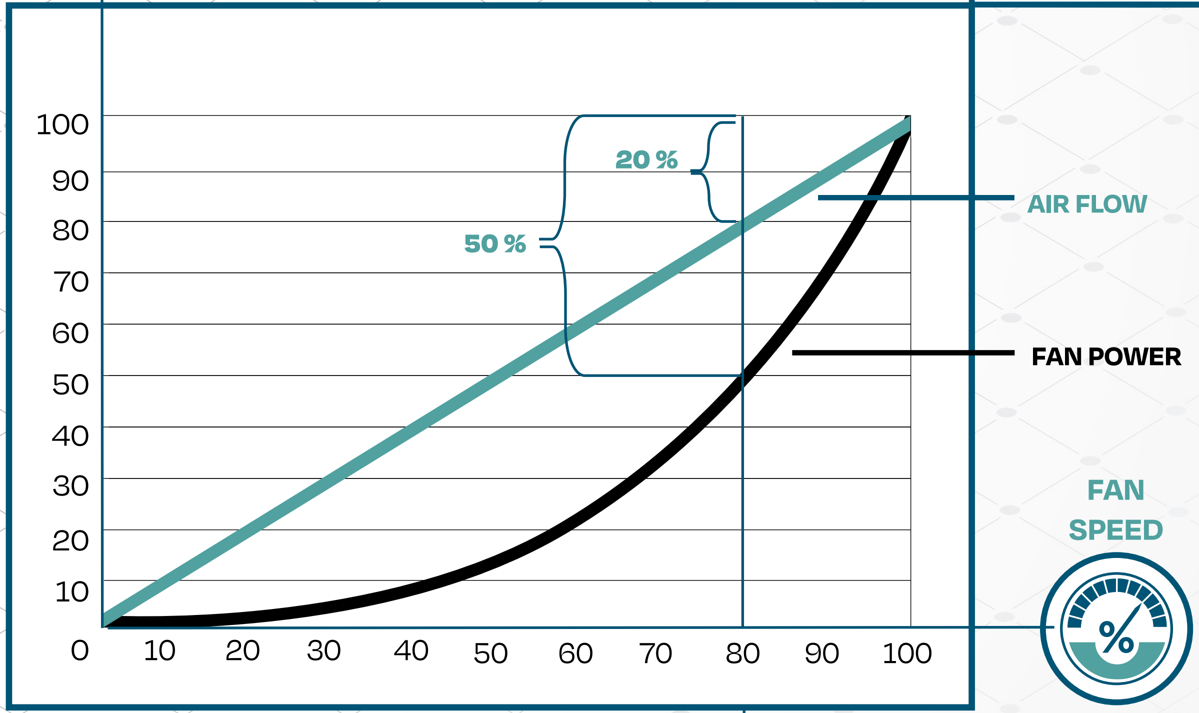
② FAN SPEED CONTROL



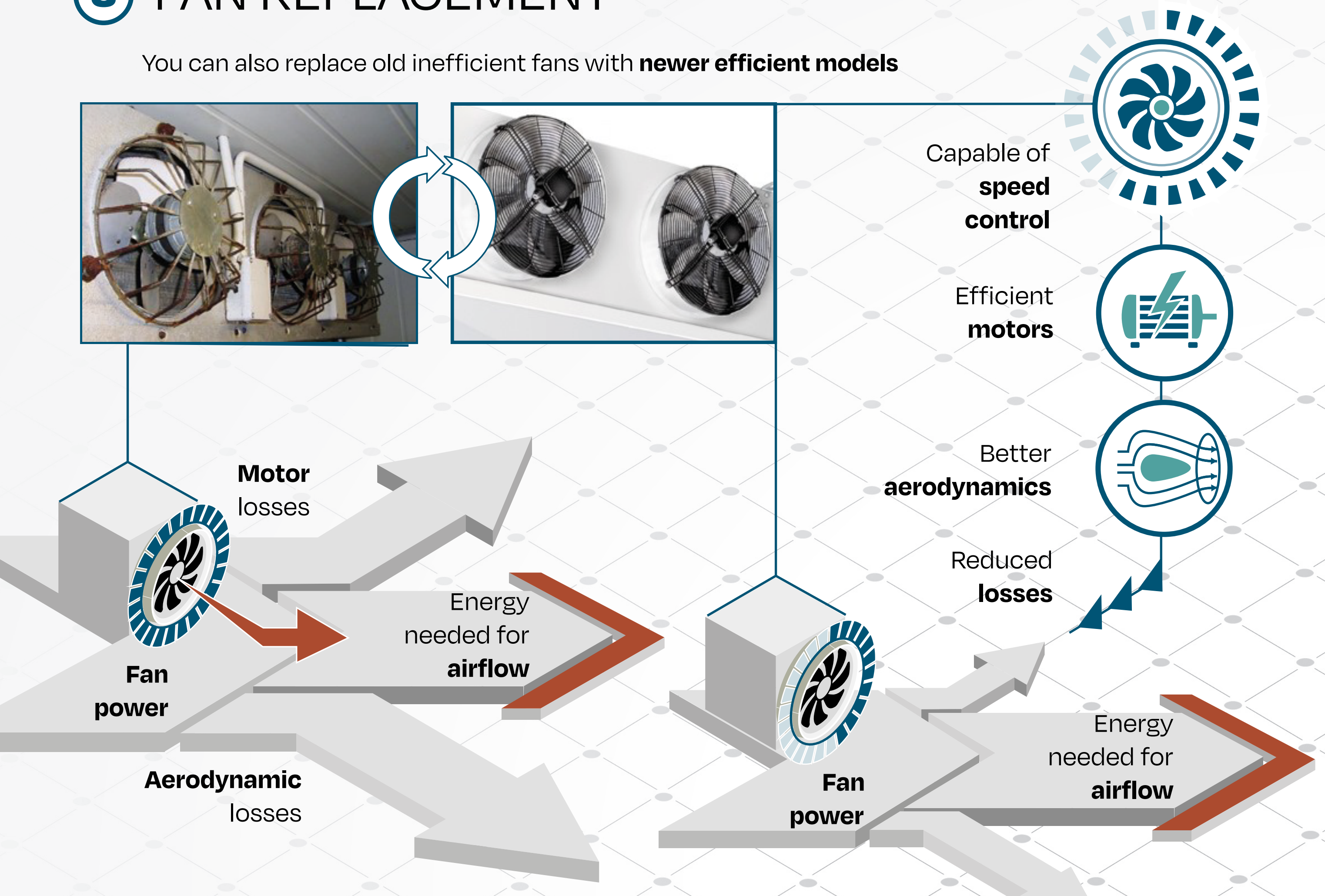


As shown by the graphs, fan power drops drastically, if air flow/speed is reduced. E.g. by reducing the air flow/fan speed by only **20 %** you can save close to **50 %** fan power.

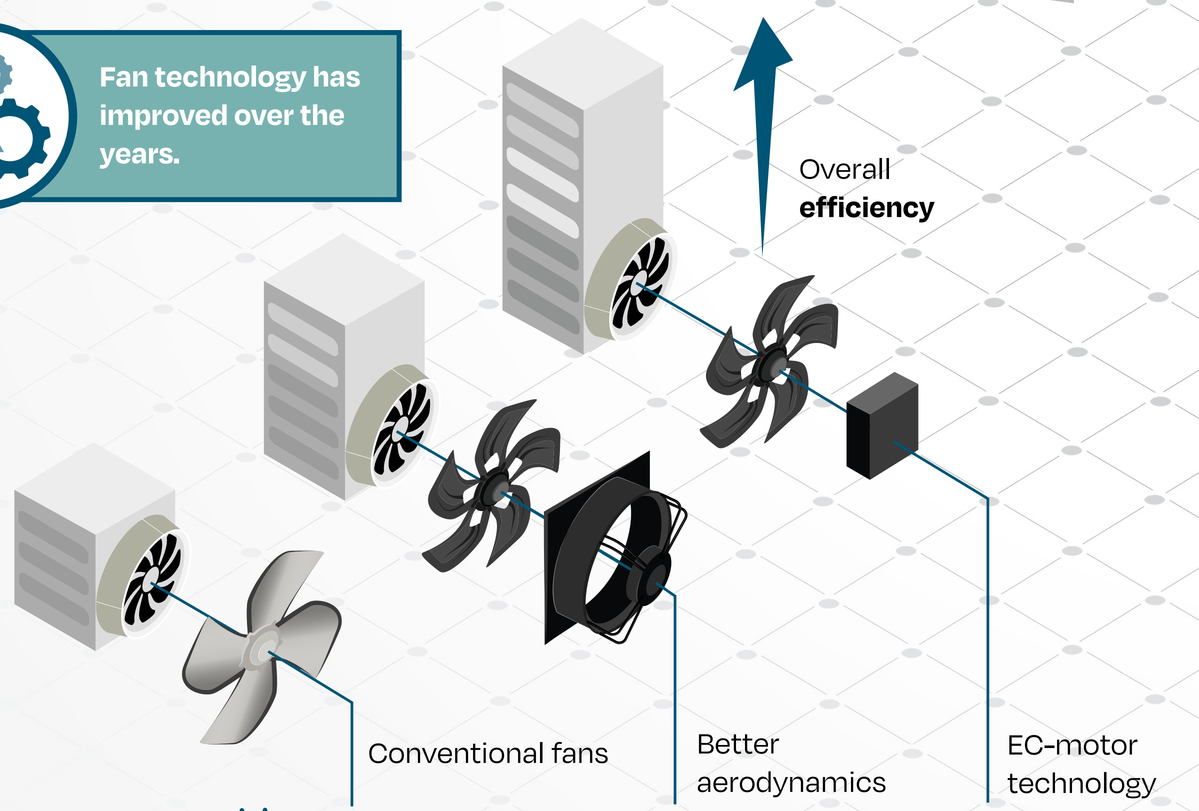
Retrofit existing fans with variable speed drive (VSD) or voltage speed control, or **replace** old fans with new **EC-fans** capable of speed control.

3 FAN REPLACEMENT

You can also replace old inefficient fans with **newer efficient models**

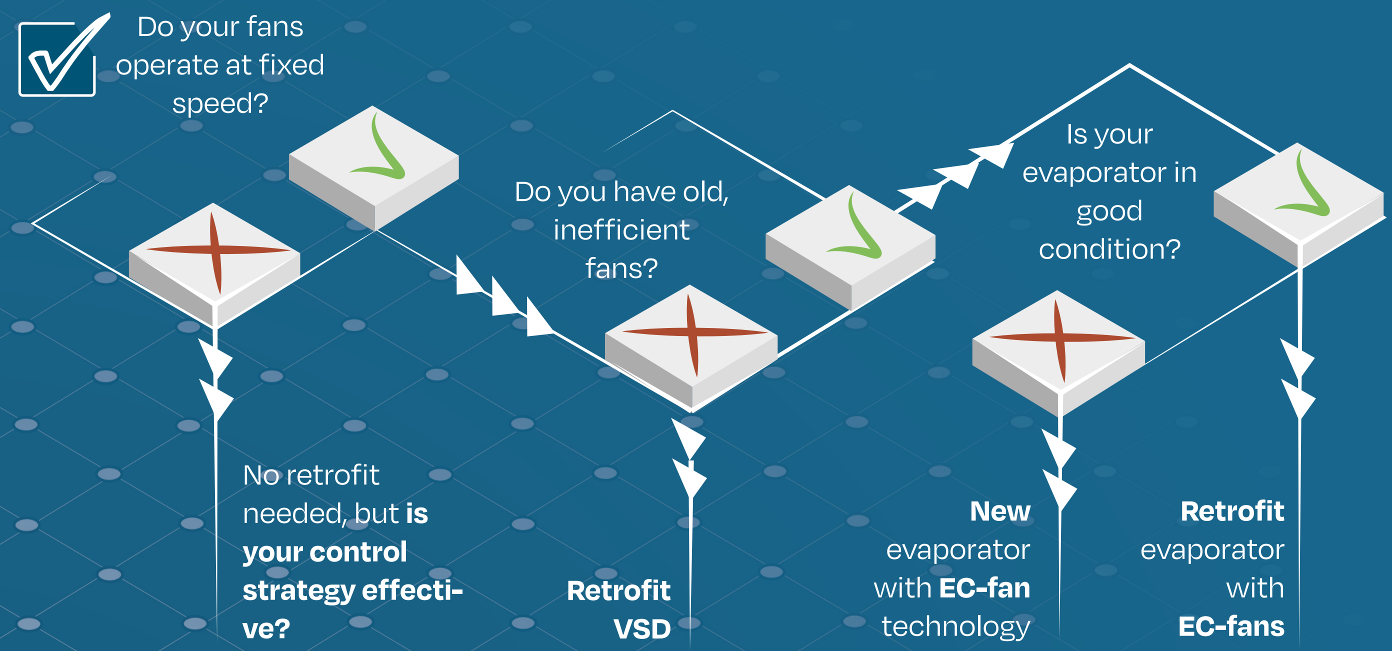


Fan technology has improved over the years.



Same as speed control, efficient fans save energy simply by consuming less power & **reducing the heat load** introduced into the cool rooms.

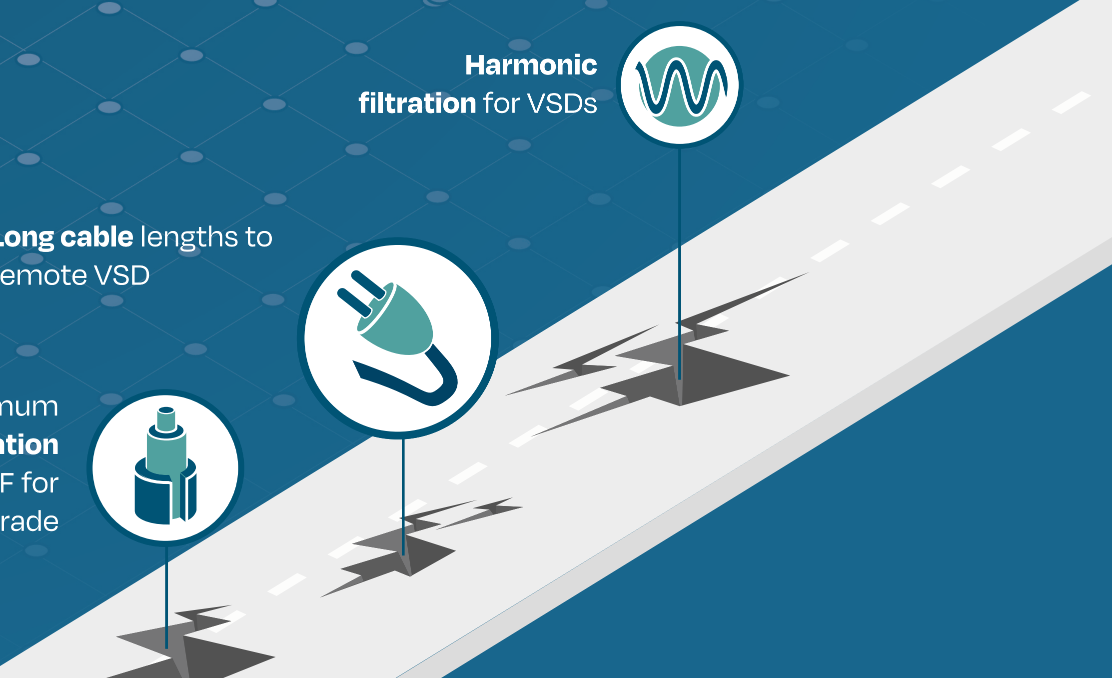
4 DOES THIS WORK FOR ME?



GOOD TO KNOW 5

- **Consult VSD supplier** to match VSDs to existing fan motors.
- Consider installing **door switches** for control logic input.
- Hardware capable of speed control is not a guarantee for energy savings! You must have **smart control strategy** to achieve this.

6 POSSIBLE POTHOLES

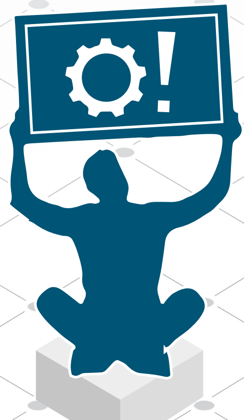


CONDENSER FAN SPEED CONTROL

LOCATION & REPLACEMENT

① HEAD PRESSURE CONTROL

After the vapour has been compressed to hot gas, it is discharged by the compressors. The **discharge pressure** often is referred to as **head pressure.**



▼

Head pressure relies on **condensing temperature**, which in turn depends on ambient conditions and condenser capacity.

▼

We cannot influence the ambient, but we can **regulate capacity using condenser fans.**

▼

Fans are designed to meet peak cooling demands at peak design temperature.

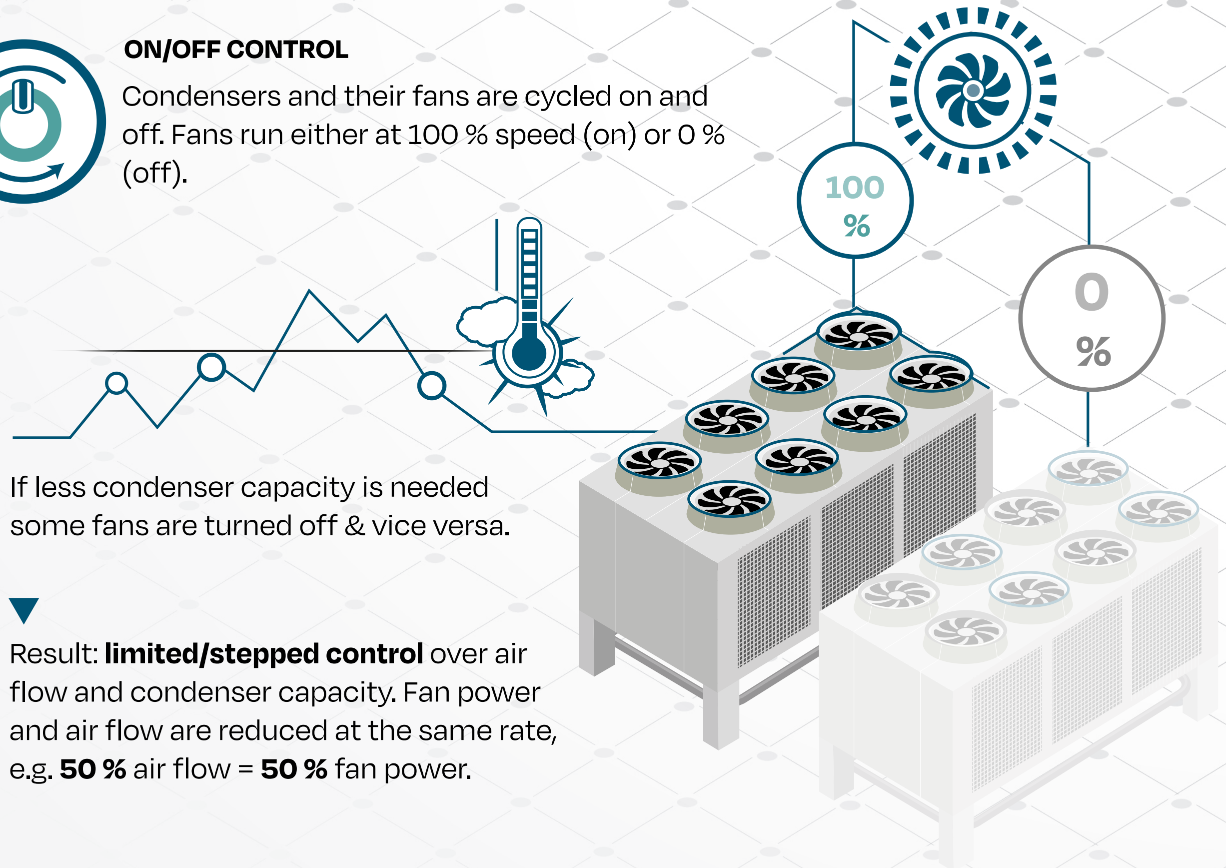
▼

If ambient is cooler than the design temperature and/or the cooling load is not at peak design load, full fan power is **not needed.**

② COMMON PRACTICE

ON/OFF CONTROL

Condensers and their fans are cycled on and off. Fans run either at 100 % speed (on) or 0 % (off).



If less condenser capacity is needed some fans are turned off & vice versa.

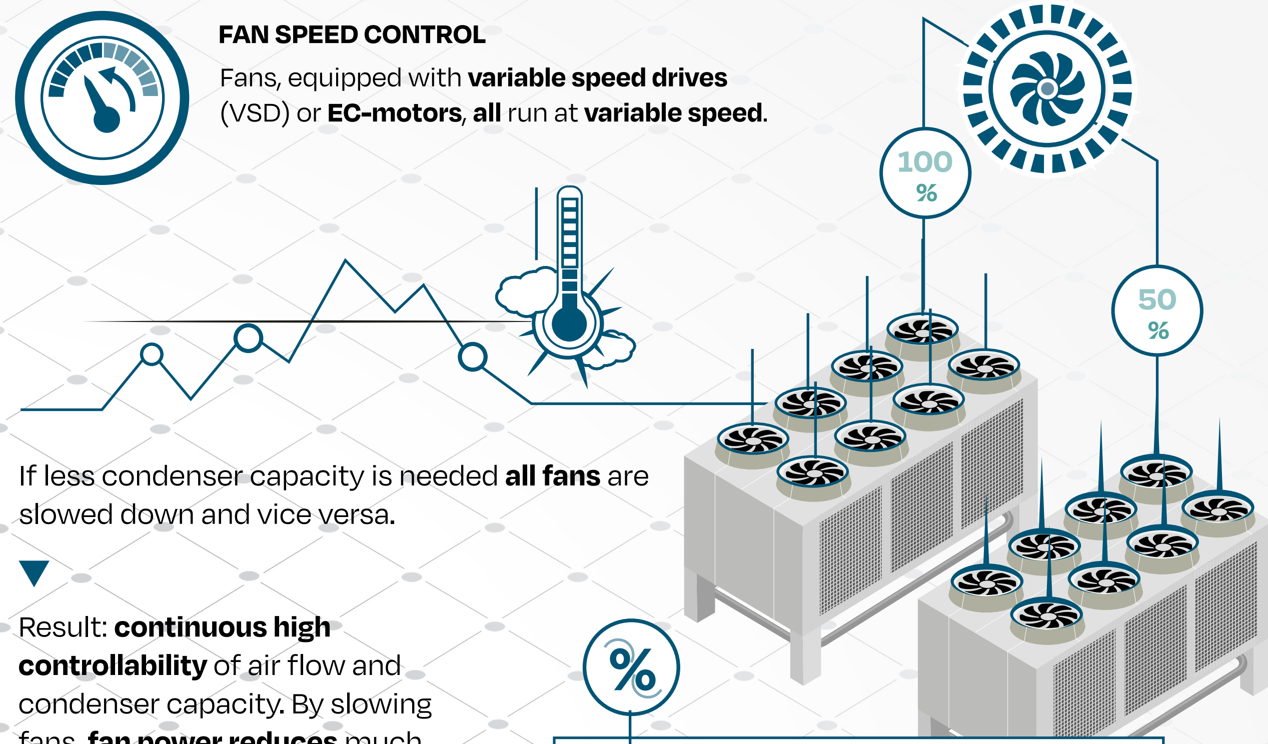
▼

Result: **limited/stepped control** over air flow and condenser capacity. Fan power and air flow are reduced at the same rate, e.g. **50 %** air flow = **50 %** fan power.

③ BETTER PRACTICE

FAN SPEED CONTROL

Fans, equipped with **variable speed drives** (VSD) or **EC-motors, all** run at **variable speed.**

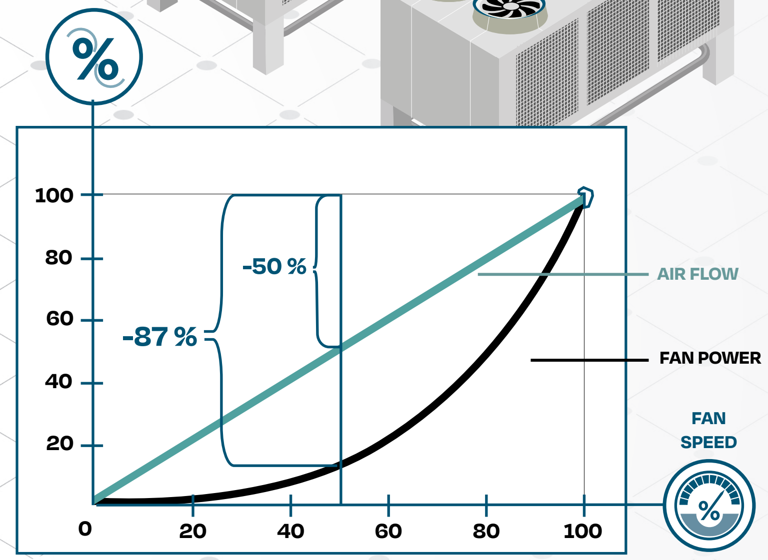


If less condenser capacity is needed **all fans** are slowed down and vice versa.

▼

Result: **continuous high controllability** of air flow and condenser capacity. By slowing fans, **fan power reduces** much quicker than air flow, see graph. **Highly reduced** fan power at part load,

50 % air flow **13 %** fan power.



④ BENEFITS

vs.

ON/OFF CONTROL	FAN SPEED CONTROL
High energy use at part load	Significantly **less energy** use at part load
Stepped, bad controllability	**Continously, highly** controllable
Higher **wear & tear due to startups**	**Smoother** plant operation and significant maintenance savings for fan belts
Noisy restarts & screeching belts	**Low** noise operation

SAVINGS
(energy & maintenance)

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5 CONDENSER LOCATION

Condenser location is vital for reliable and efficient operation.

Poor airflow caused by:

- **recirculation**
- **blockages**
- **incorrect installation**

Leads to **high** condensing pressure

High compressor power consumption

High compressor wear & increased **risk of system failure**

Use the cool ambient air

Make sure air in- and outlets are **unobstructed!**

Do not fit into basements/ enclosed spaces!

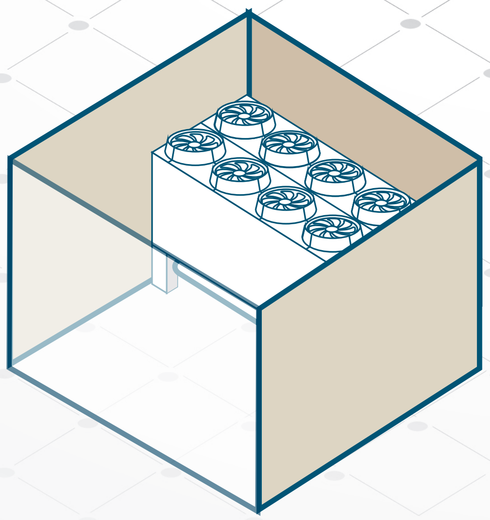
Inlet air temperature of 30.7 °C even though 22.3 °C fresh air is coming in from outside (+8.4 K increase!)

Condenser is located **inside enclosure.**

BAD EXAMPLES

Heated outlet air is re-circulated into air-inlet

Head pressure rises & compressors must work harder resulting in higher energy consumption



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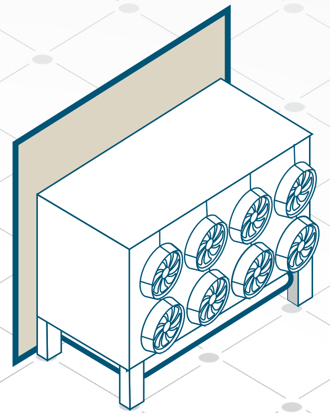


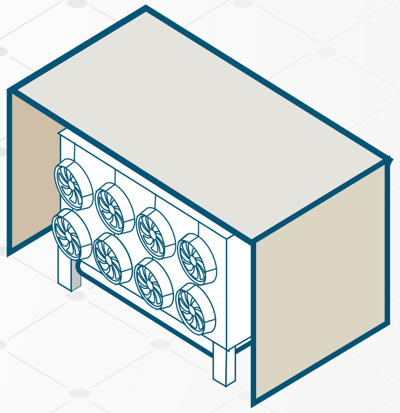
Air-supply is **obstructed**

Fans are working against unnecessary resistance.

Warm exhaust air is not properly discharged & heats up condenser.

Condenser in **ceiling space**

Not only **enclosed,** but **ceiling temperatures** become very high, especially during summer.



GOOD EXAMPLES:

ROOF MOUNTED

SHADED

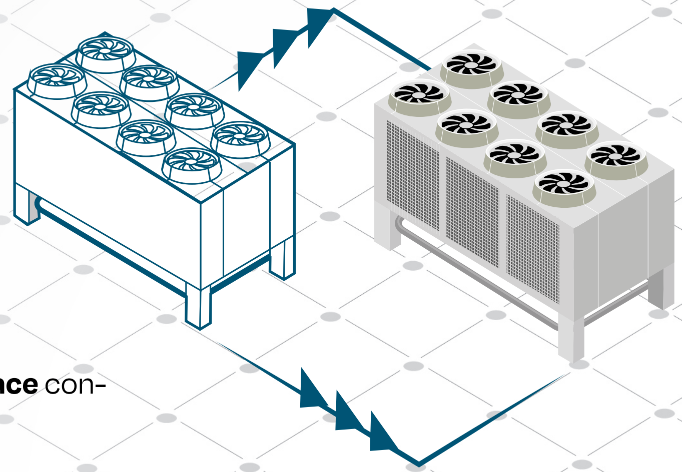
WELL VENTILATED

6 CONDENSER REPLACEMENT

Blocked & deteriorated **coils** do not transfer heat well.

Condensing temperatures rises when coils are **fouled/ damaged.**

Clean/replace con-densers!



DOES THIS WORK FOR ME? 7

Condenser fan speed control is always a good idea! But ask yourself:

1 Is my condenser in good condition?

2 Does my condenser get plenty of cool outside air?

Replace condenser and **relocate to outside** or onto roof:

Relocate condenser to outside or onto roof.

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8 GOOD TO KNOW

If you cannot easily see **check the condenser coil** surface because it is inaccessible, then air will not get there either!

Check that all condenser fans **are working** - sometimes a single fan failure goes unnoticed.

Water sprays, splashed rain water, dust, chemicals, salt in the air, plastic bags and bits of paper, grass seeds and leaves **can all damage or block the coil.** inspect regularly.

9 POSSIBLE POTHOLES

Installing EC-fans or VSDs without **suitable controller or implementing poor control logic that constantly ramps fans up and down.**

Feasibility of VSDs on numerous very small units can be questionable.

Make sure bigger compressor racks and their condensers are equipped with VSDs.

Long cable lengths to remote VSD

Fin damage during cleaning. leave this to the professionals!

Minimum **insulation standard** class F for VSD-upgrade

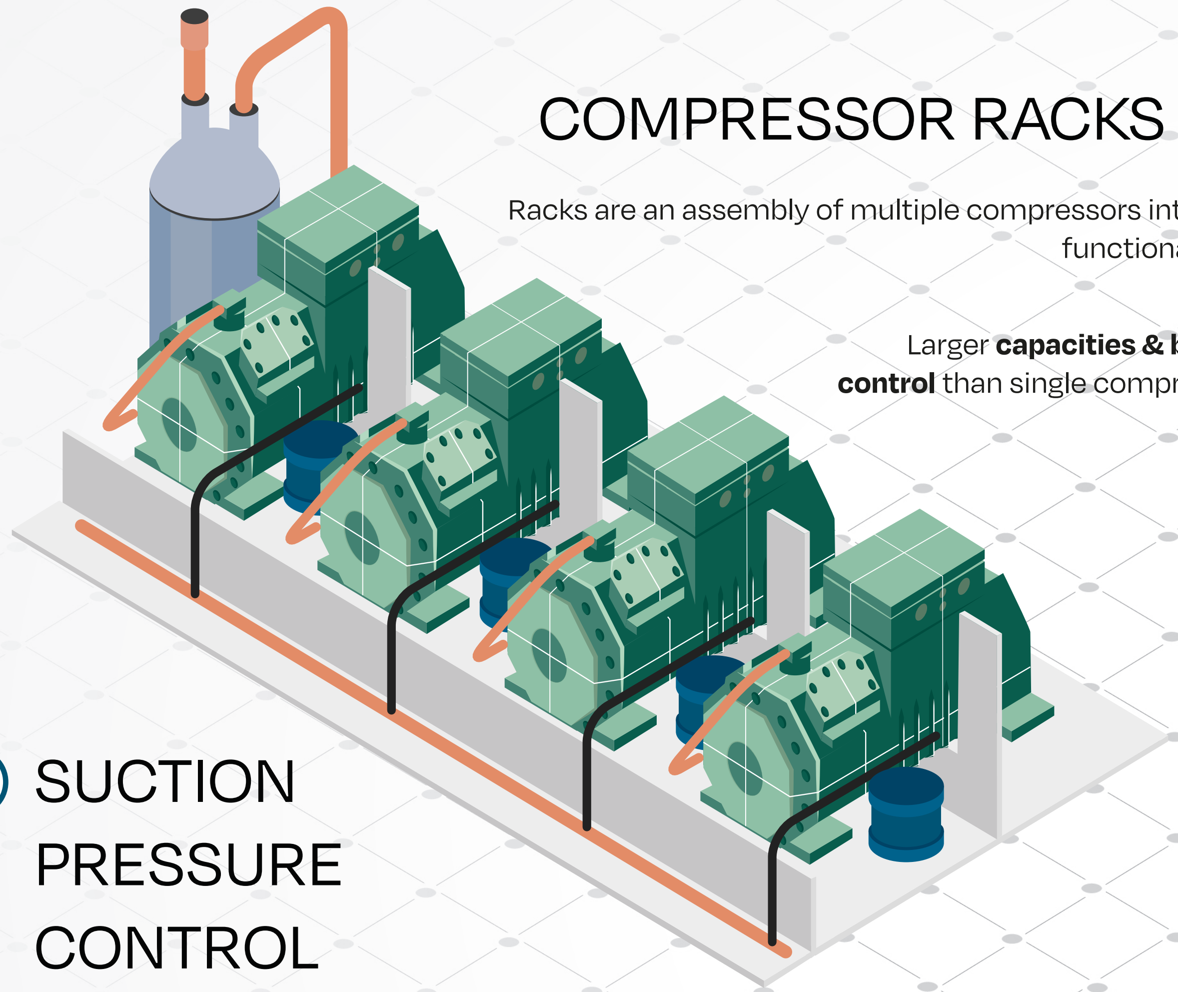
Harmonic filtration for VSDs

Undersizing replacement condenser!

Design **for 10 Kelvin** or less difference between condensing & ambient temperature..

COMPRESSOR SPEED CONTROL & STAGING

COMPRESSOR RACKS ①



Racks are an assembly of multiple compressors into one functional unit

▼

Larger **capacities & better control** than single compressor units.

② SUCTION PRESSURE CONTROL

Suction pressure is the pressure at which the compressors suck in the vapour coming from the evaporators/expansion valves.

Suction pressure is **controlled by compressor operation.**

The more **cooling load** is on the system, the more **refrigerant evaporates** inside the evaporator where it would lead to a suction **pressure increase**, if it is not removed.

So, the compressors must suck up as much vapour as is being generated by matching their capacity to the vapour/refrigeration load

This means if more vapour is coming from the evaporator and **pressure rises**, compressors must **ramp up** their capacity to take in more vapour. On the other hand, if pressure drops, so should compressor capacity.

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How compressor capacity is managed depends on the **control mechanisms at hand.** Let's have a look at the three relevant control mechanisms for commercial-type compressors and how we can improve energy efficiency and savings.

② ON/OFF CONTROL

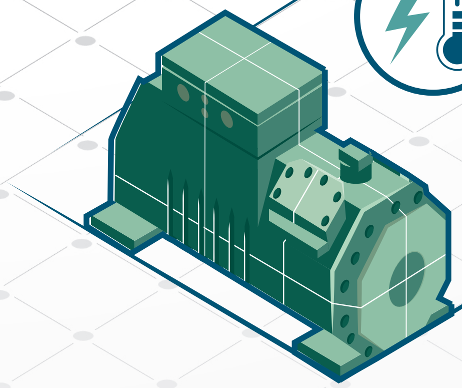
The **simplest but most inefficient** way to run compressors is by turning them on and off with fixed speed. Once suction pressure rises above an upper threshold, a compressor turns on and sucks in the vapour until suction pressure has dropped to a lower threshold and the compressor turns off again.

- Compressors run at **100 % or 0 %.**
- Compressor capacity is **not equal** to actual cooling demand.
- Single compressors are turned on/off **more frequently.**
- Bad staging: same compressor is **short-cycled.**

→

- Compressor **wear**
- **High energy demand** over time
- **costly** operation

EXPLANATORY NOTE:



When **turned on** electric motors draw high starting currents, heat up and consume more power contrary to **steady operation.**

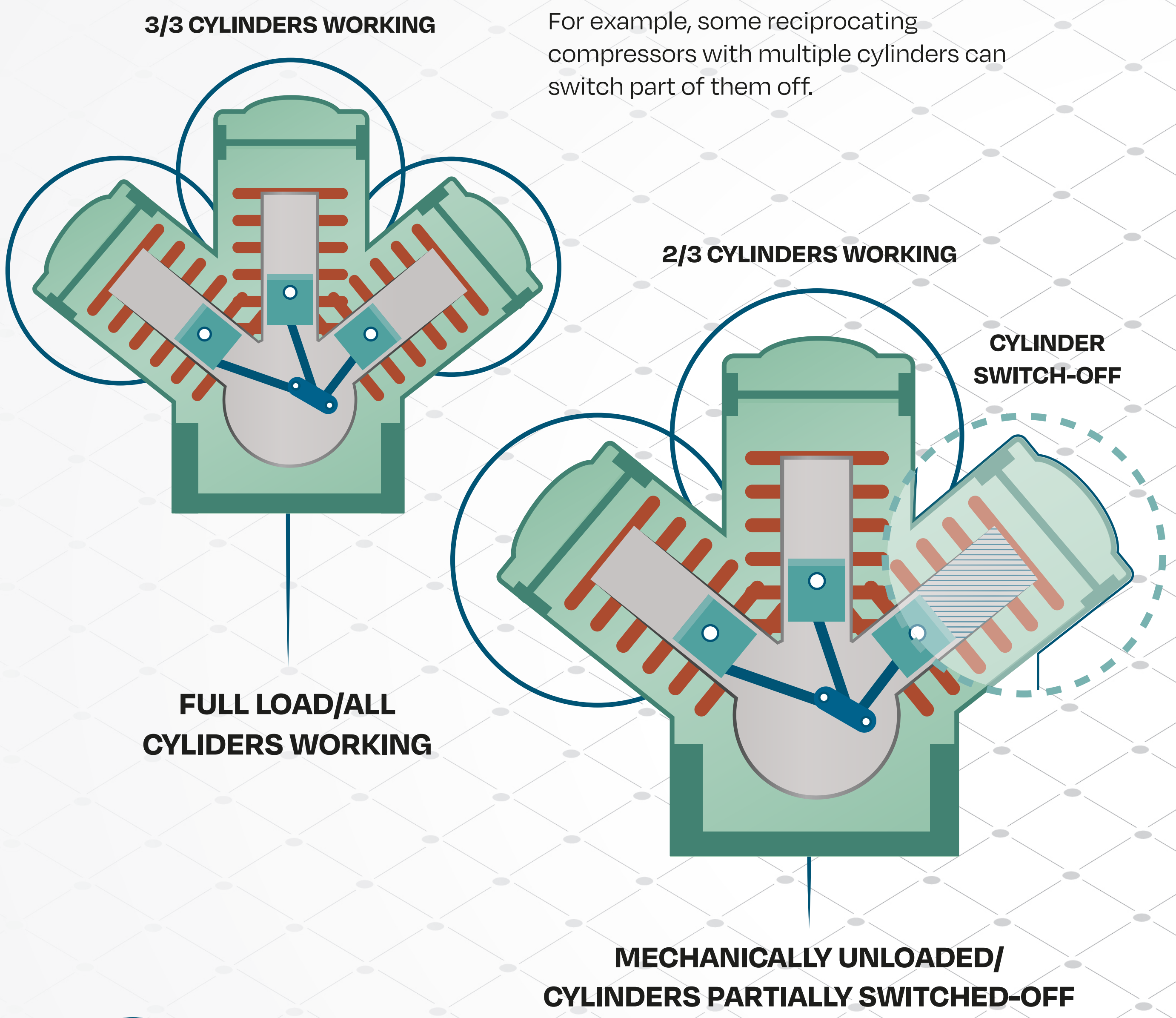
Stresses motor & shortens its **life span**

Minimize frequency of start/stop cycle!

④ MECHANICAL UNLOADING

A better but still quite inefficient way of controlling compressor capacity is by **mechanically unloading**, which some compressors are capable of. By mechanically unloading compressors still run at **fixed** speed but can shed some of their capacity to operate at **part load** and **avoid short cycling.**

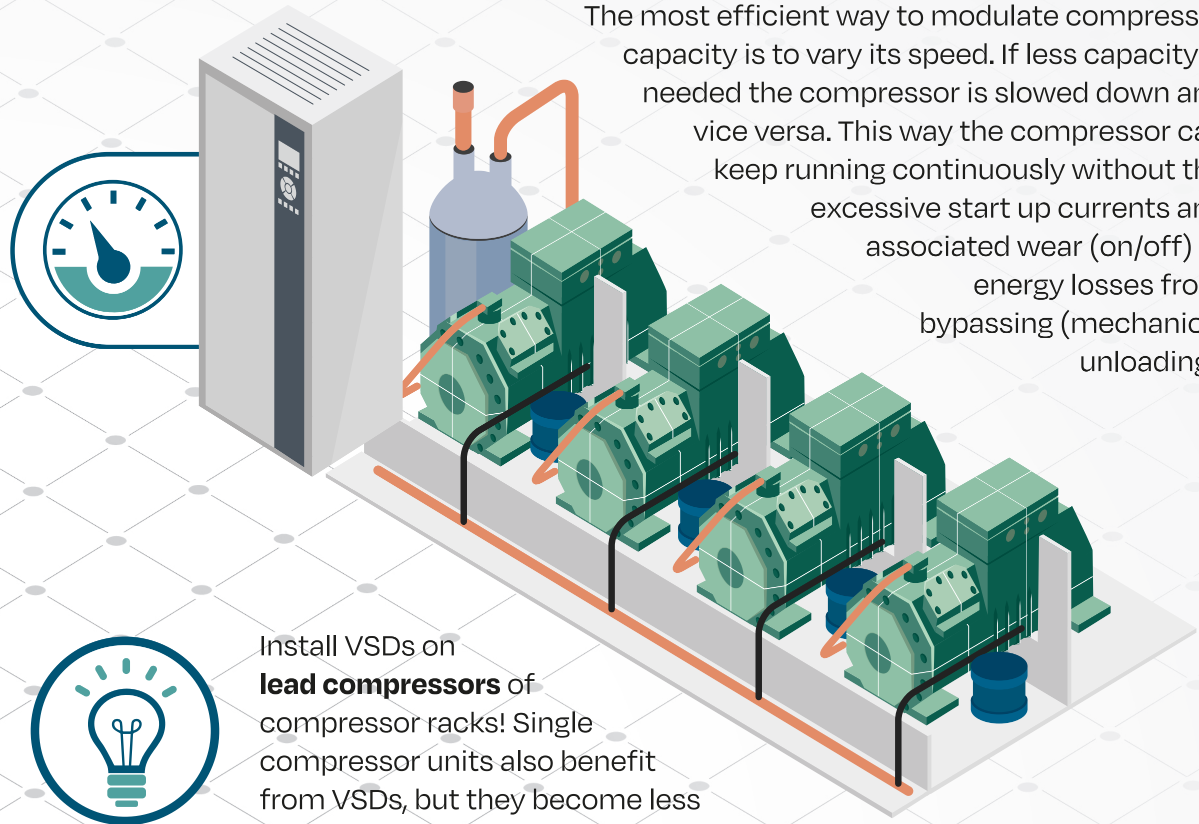
For example, some reciprocating compressors with multiple cylinders can switch part of them off.



Mechanical unloading still comes with considerable **energy losses** and therefore **higher operational costs.**

VARIABLE SPEED CONTROL ⑤

The most efficient way to modulate compressor capacity is to vary its speed. If less capacity is needed the compressor is slowed down and vice versa. This way the compressor can keep running continuously without the excessive start up currents and associated wear (on/off) or energy losses from bypassing (mechanical unloading).



Install VSDs on **lead compressors** of compressor racks! Single compressor units also benefit from VSDs, but they become less feasible.

Extended compressor **life span & energy** savings.

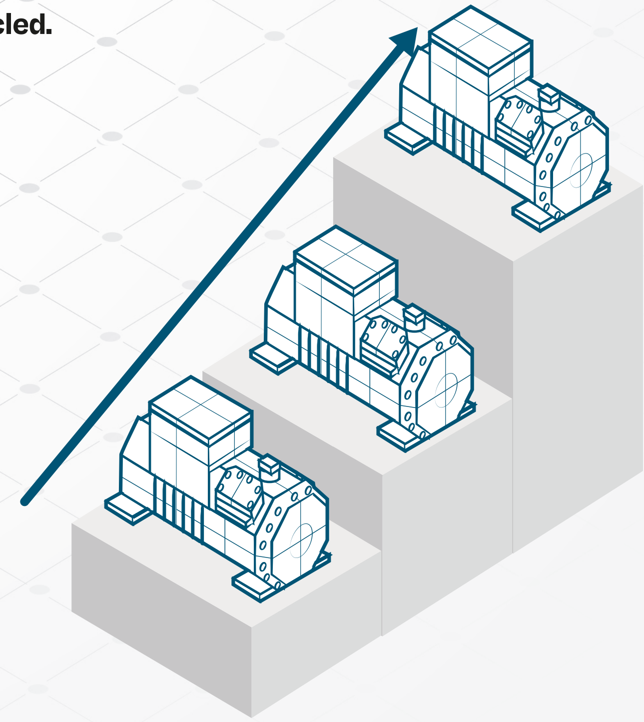
COMPRESSOR STAGING ⑥

Compressors are **not short-cycled.**

Compressor **duty is rotated** to spread wear evenly.

Compressors with VSDs take the **lead duty**, modulating their capacity via speed control to match cooling demand, allowing all other compressors to run fully loaded.

→ **minimize mechanical unloading/compressor cycling.**



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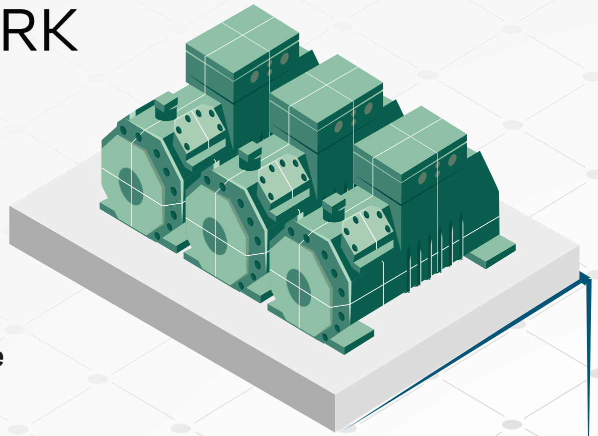
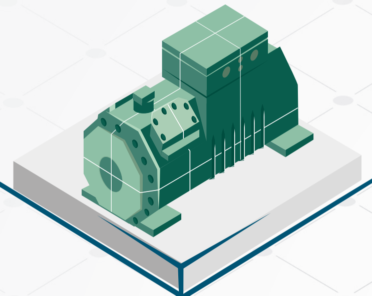
7 DOES THIS WORK FOR ME?

CHECKLIST



Do you have a **compressor rack** or **single compressor** units?



Staging **not possible**. VSDs might help single compressors, but are **less feasible** compared to racks.

Do you have a **good** staging strategy with variable speed control?

No **modification** needed

Implement/improve cont-rols!

Are your compressors in **good condition** and only a few years old?

Consider a **plant upgrade** with new compressors and make sure at least one of them is equipped with a vsd. **Do not** invest in a vsd on an old worn out compressor.

Retrofit at least one VSD to **the biggest compressor** (or more) and implement control logic.

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8 GOOD TO KNOW

- Equip at least the compressor with the **biggest capacity** with a VSD. This way it operates as the lead compressor while all others run at 100 % or 0 % but on/off cycling is reduced to a minimum.
- Installing VSDs on more than one compressor allows you to rotate lead duty and spread compressor wear. But you do not need to equip all compressors on a rack with VSDs either. In fact this can be counterproductive as VSDs have small energy losses themselves.
- vsds can operate your compressors at **higher speeds** (60 Hz) and with it increase their capacity.
- A good staging control makes sure recently turned off motors stay off for a minimum time frame. This lets them cool down and avoids overheating to **reduce stress**.
- **Good band-aid**: If your compressor is excessively large, you can fix that problem. instead of replacing it you can run it **slower** and generate the same outcome.

POSSIBLE POTHOLES 9

Smaller freon refrigeration plants as covered by this guidebook only have **short lifespans** of 10 to 15 years.

▼

Makes it harder for investments into vsds to pay off.

VSDs need to be kept **clean.**

Make sure you have the **right control system** (suitable rack controller) that can be programmed for this control.

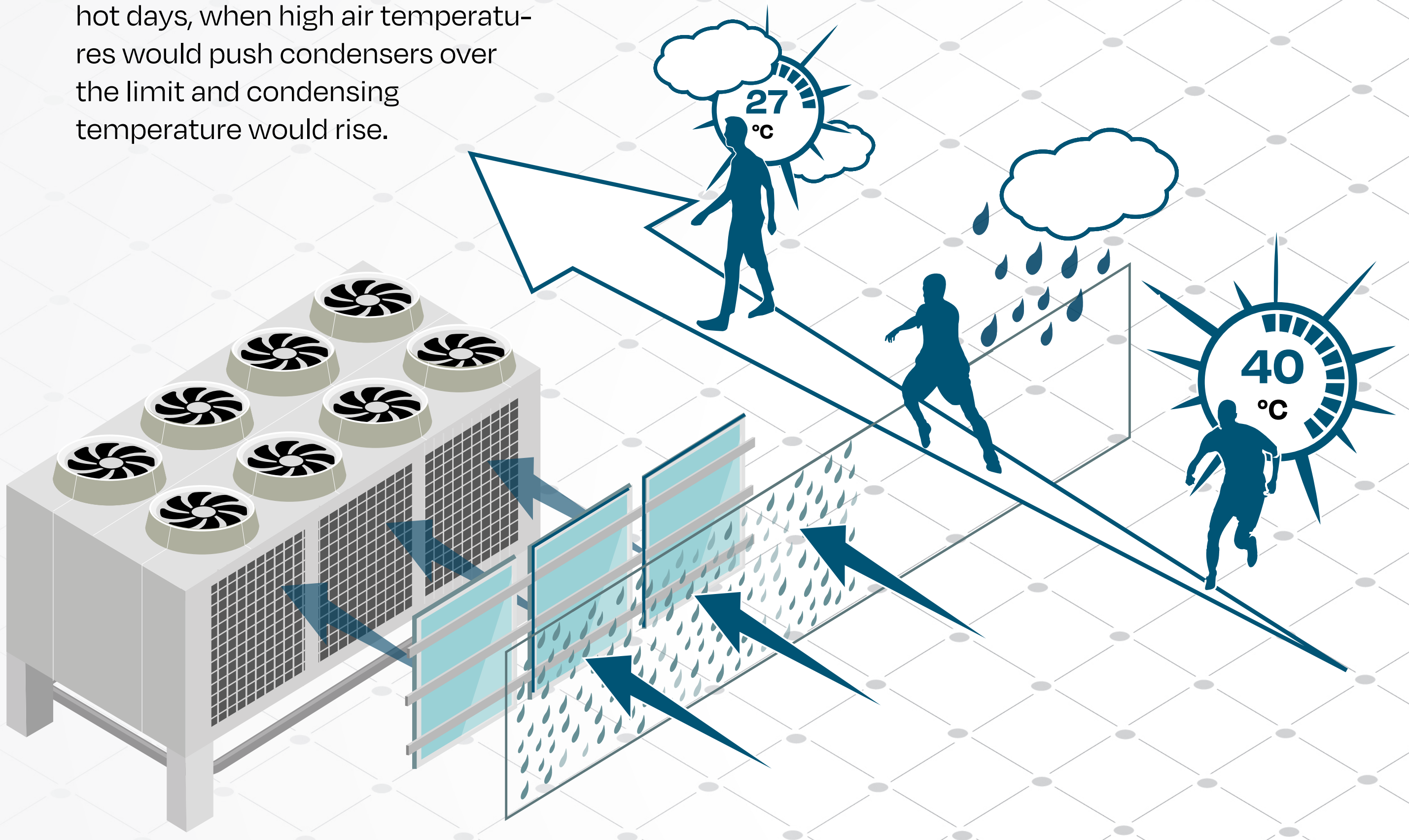
VSDs need to be in a **cool, clean environment** or they could trip out on hot days.

Cheap VSDs may cause **harmonic problems** on site that can damage electronics

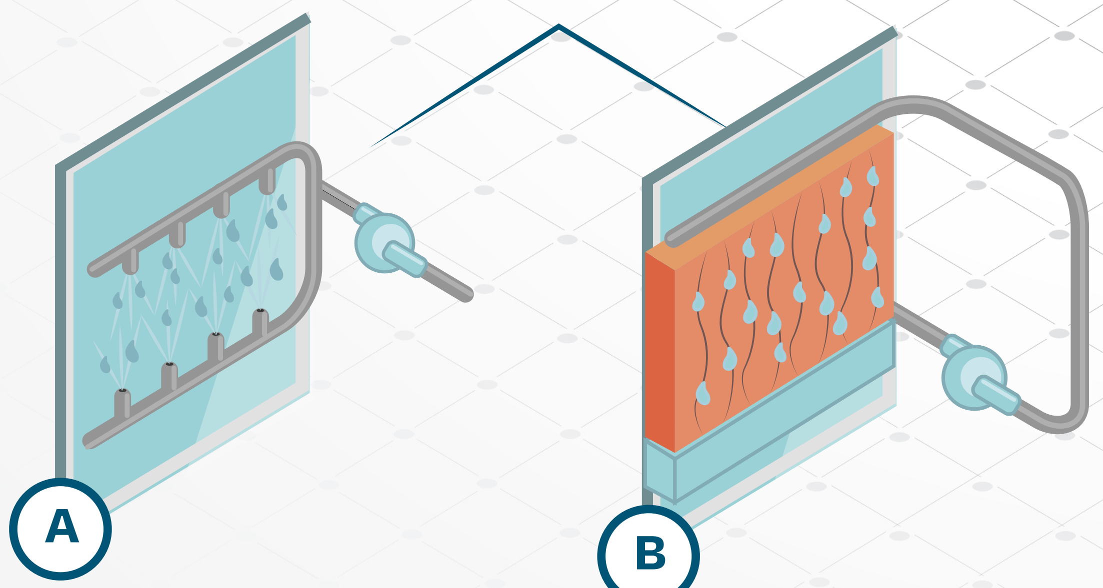
ADIABATIC COOLING FOR CONDENSERS

1 HOW DOES IT WORK?

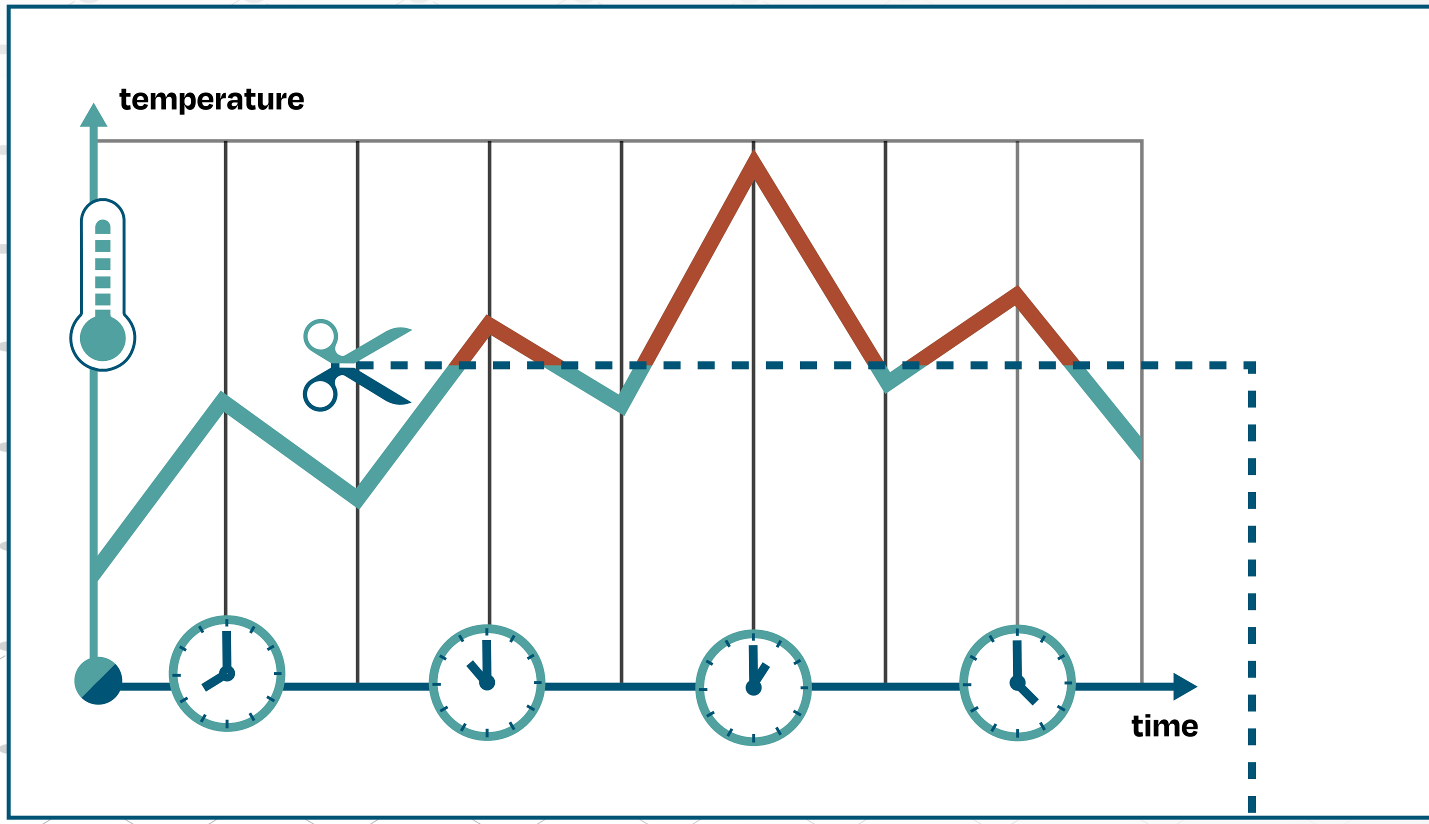
Water spray systems **(A)** or wetted pads **(B)** cool the condenser intake air on hot days, when high air temperatures would push condensers over the limit and condensing temperature would rise.

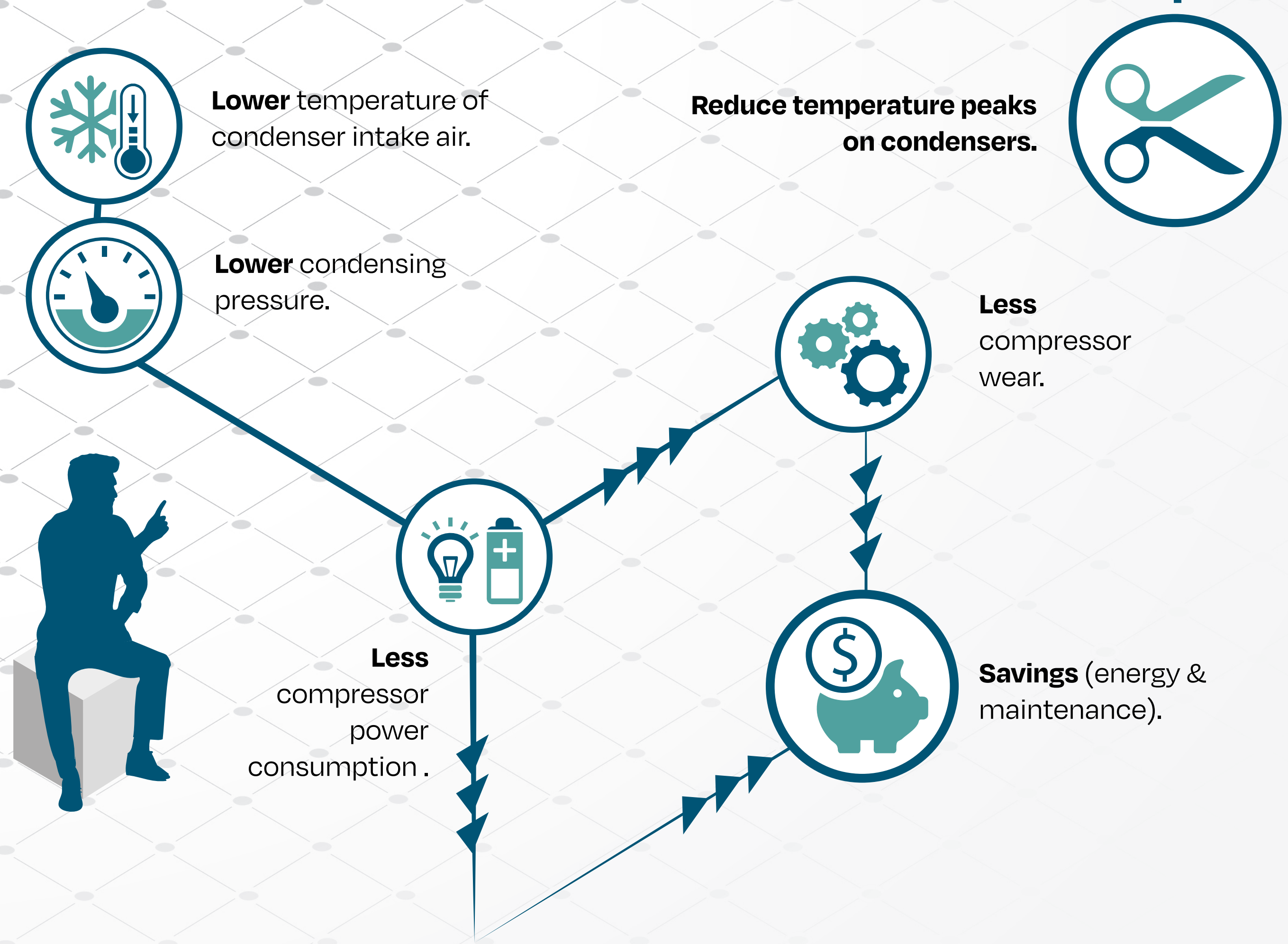


Available systems pad or spray with pump



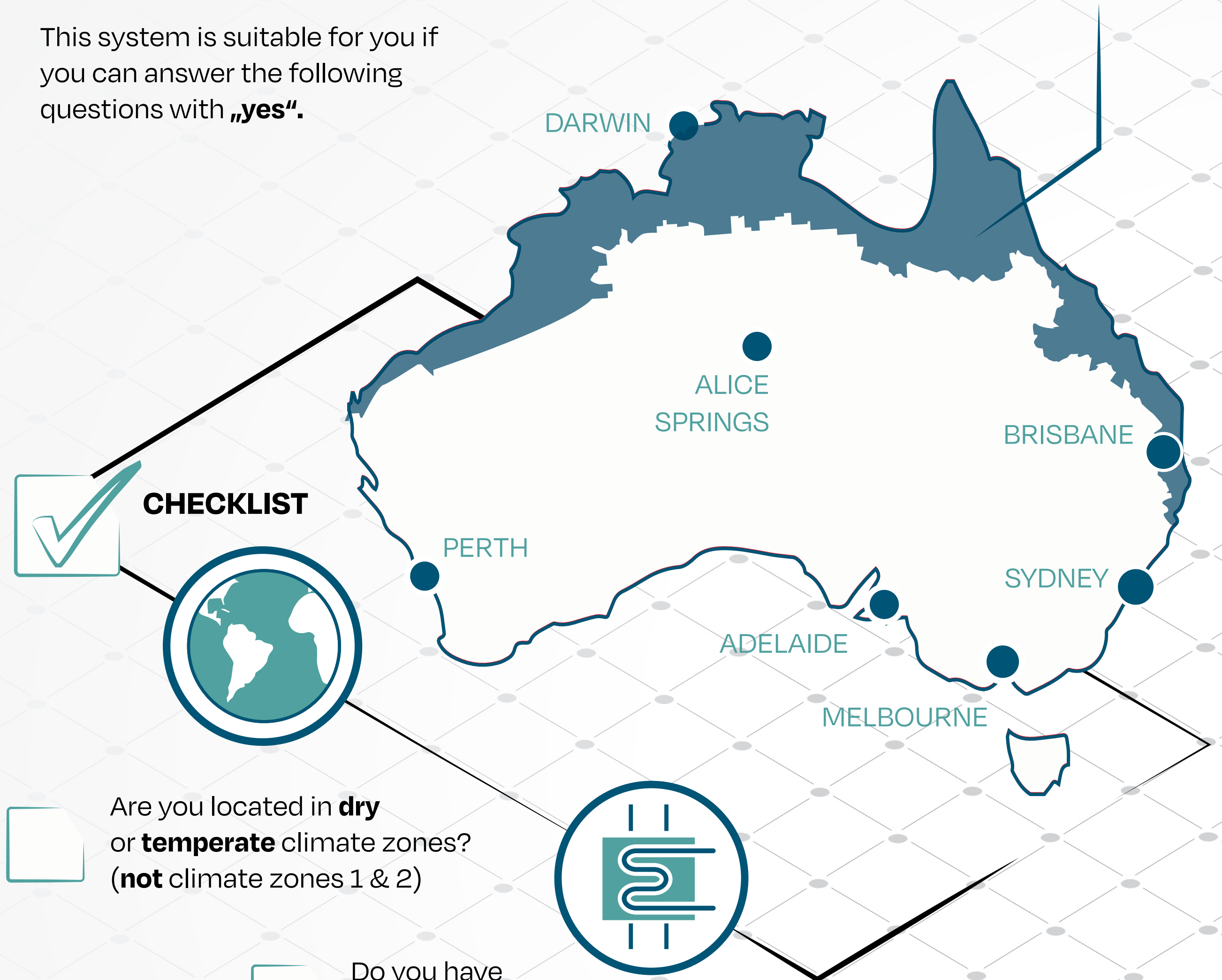
2 THE BENEFITS





③ DOES THIS WORK FOR ME?

This system is suitable for you if you can answer the following questions with **„yes“.**

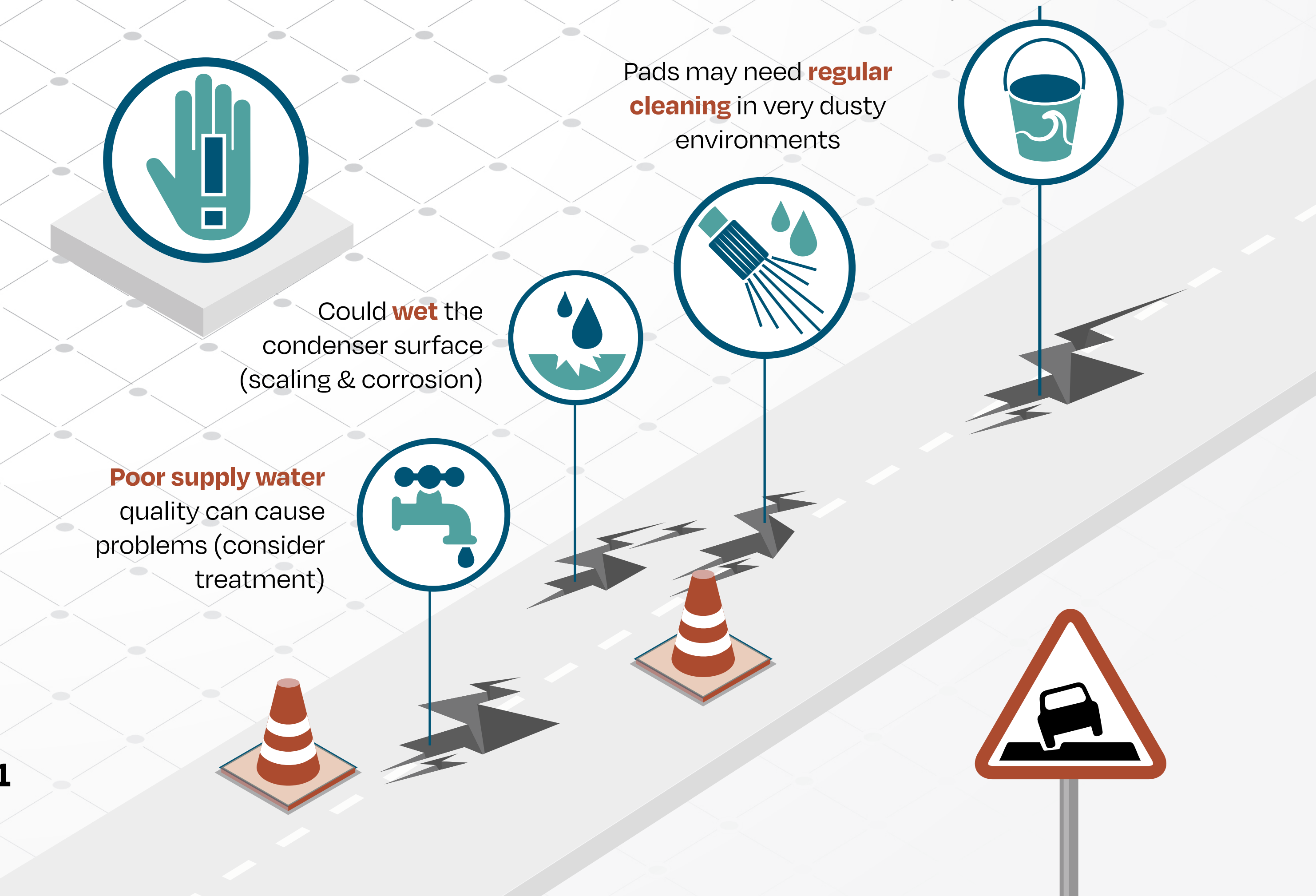


- [ ] Are you located in **dry** or **temperate** climate zones? (**not** climate zones 1 & 2)
- [ ] Do you have **air-cooled** condensers?

GOOD TO KNOW ④

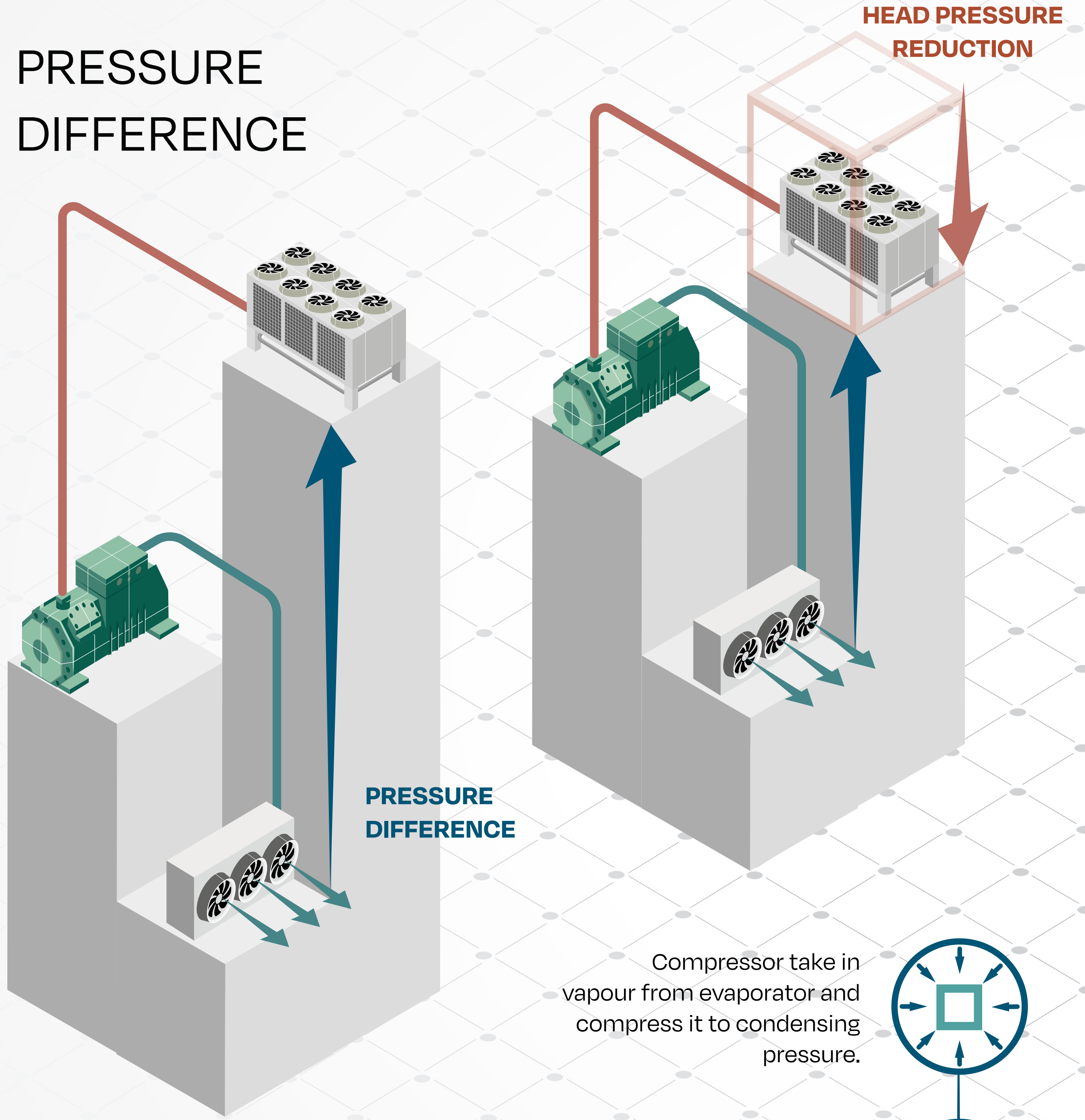
- Spray-type systems are best for retrofits to existing condensers or on new/replacement condensers.
- Pad systems are for new/replacement condensers only (not retrofittable).
- Trigger temperature that determines when adiabatic cooling turns on should be a compromise between water and energy consumption.
- Adiabatic cooling can help to reduce demand costs (see "How to interpret your electricity bill" in the How-To Manual) by reducing energy demand during production load peak which typically coincides with high temperatures around midday.

⑤ POSSIBLE POTHOLES



FLOATING HEAD PRESSURE CONTROL & EXVs

1 PRESSURE DIFFERENCE



Compressor take in vapour from evaporator and compress it to condensing pressure.

Condensing pressure depends on ambient air temperature and condenser fan operation. The latter is used to actively control condensing pressure, see Condenser Fan Speed Control, pg. 16 - 17.

If condensing pressure is high, so is the pressure difference which must be overcome by the compressors. Also, cooling capacity is reduced!

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The compressor discharge, also commonly referred to as head pressure, is driven by the condensing pressure, reducing the latter also results in a head pressure reduction.

2-3 %

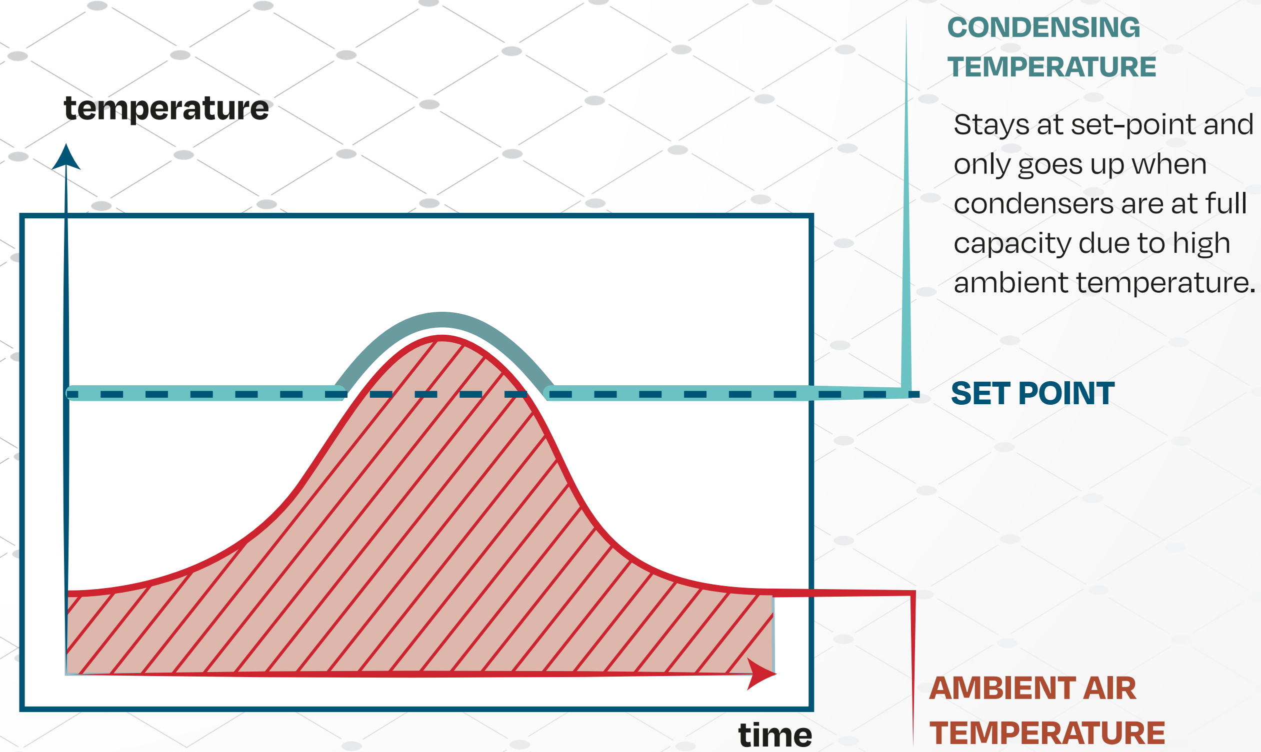
Refrigeration requires 2-3 % more energy per Kelvin increase in condensing temperature. E.g. dropping condensing temperature from 30 °C to 20 °C (= 10 K) would result in a 20-30 % energy saving for the entire high stage!

Condensing/head pressure should be as low as possible to save energy.

STANDARD PRACTICE 2

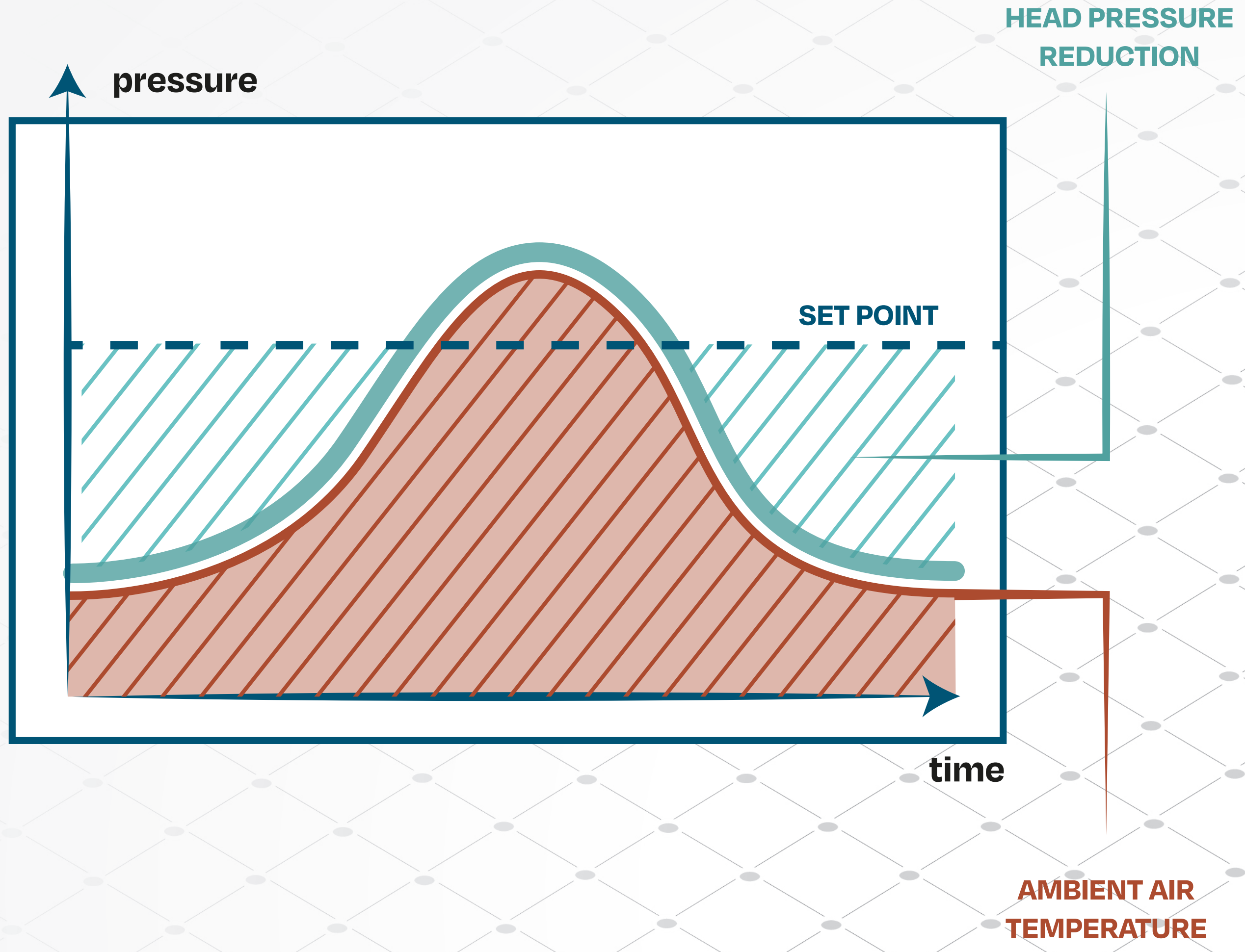
Usually, head pressure is maintained at a set fixed level.

Maintaining a set point pressure is easier from a control perspective and requires very few sensor inputs for the controller.



Lower ambient temperatures have no positive effect on head pressure & compressor power consumption.

3 FLOATING HEAD PRESSURE CONTROL



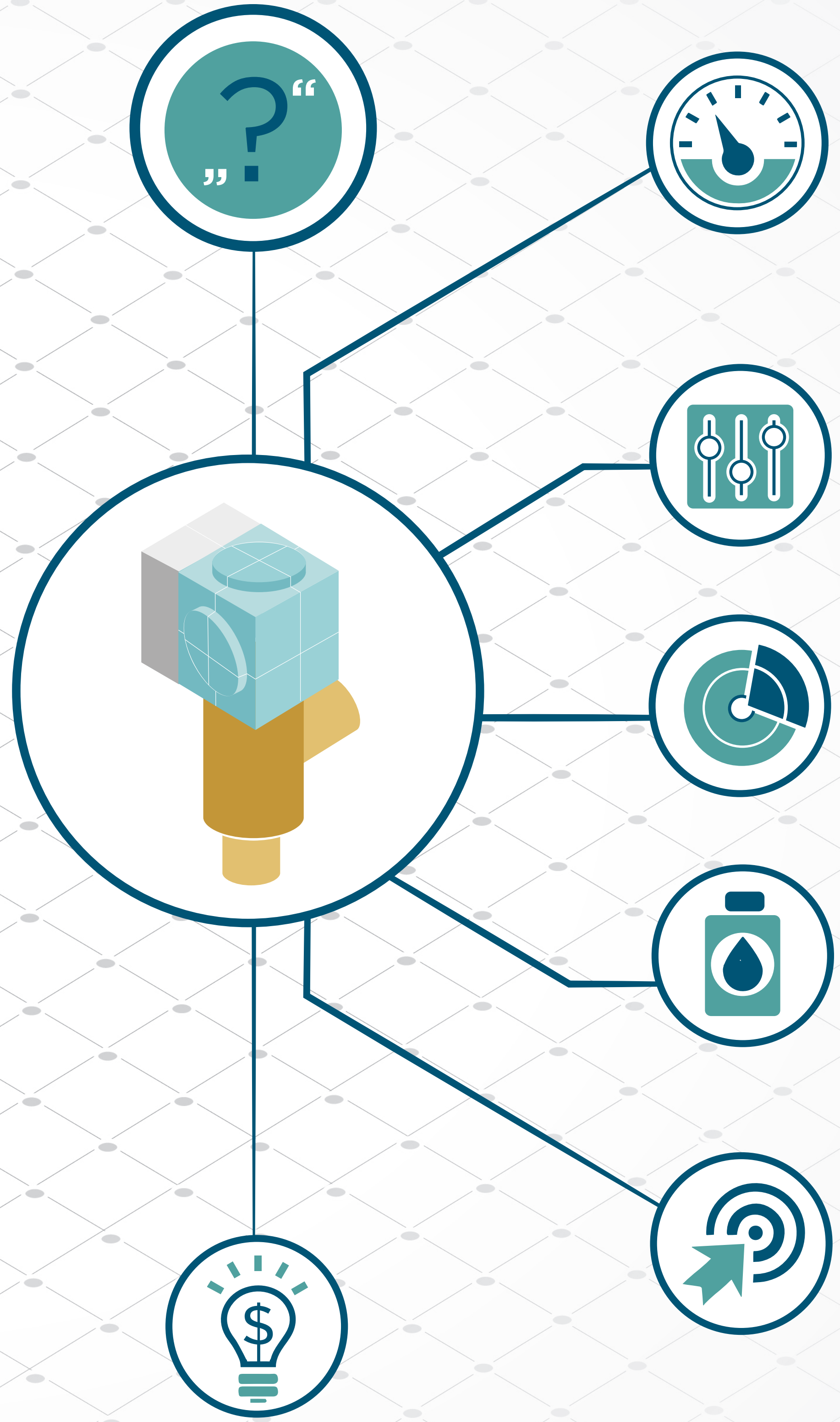
Instead of maintaining a constant head pressure, it is varied in accordance with ambient air temperature.

Requires installation of temperature sensors & EXVs and implementation into the control system.

This means fans run faster to drop condensing pressure and save compressor energy in turn.

→ Efficient condensers and plenty of condenser capacity benefit Floating Head Pressure Control by reducing energy penalty from higher fan use.

4 WHY ELECTRONIC EXPANSION VALVES?



They can operate with **less pressure difference** than TXVs which enables the gainful use of floating head pressure control.

Better controllability as slow TXVs can become unstable.

Wider **part load variation** than TXVs.

Injects exactly the **right amount** of refrigerant.

Precise control for a fast and accurate response to load change.

Further energy savings on top of floating head pressure savings.

DOES THIS WORK FOR ME? 5

Do you have a **freon plant**? If yes, floating head pressure control and EXVs are a good way to make your plant run more efficiently.

It makes better financial sense if your **plant is new** (<5 years) and/or in good condition.

If that is **not the case**, you might consider a **plant upgrade** or a **replacement.**

Make sure your new plant makes full use of floating head pressure control. There are considerable savings achievable with **short pay backs.**

6 GOOD TO KNOW

- EXVs allow for an **adaptive defrost.**
- There are **two types** of exvs: **pulsing valves** (like danfoss akv) and **stepper motor valves** (like carel e3v). Pulsing valves are better at clearing oil out of evaporators, whilst stepper motor valves offer more stable control, especially on smaller evaporators.

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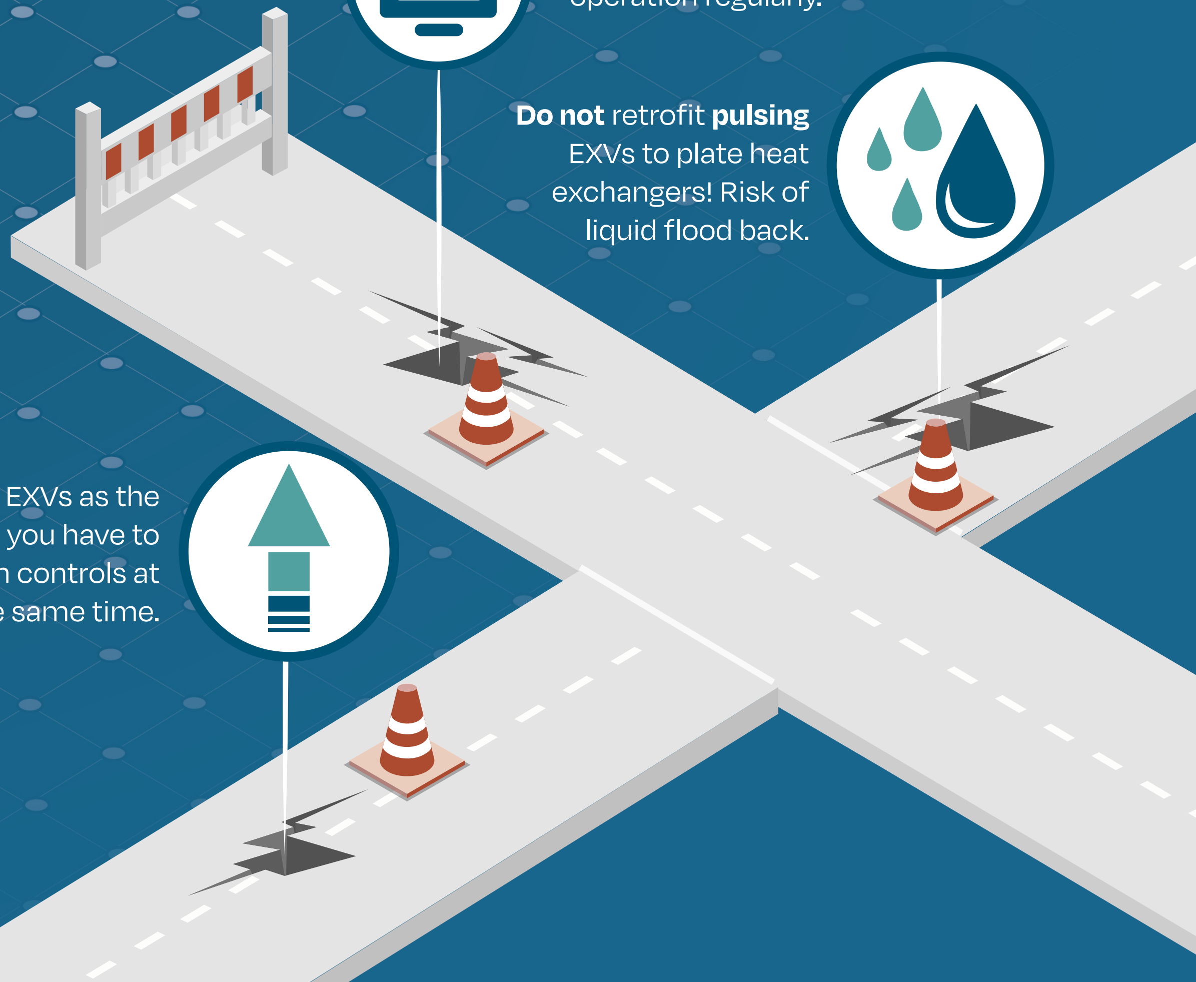
- Some EXVs need an **upstream solenoid valve** as they do not shut reliably. Check with supplier.
- Correct **temperature sensor location** is important for EXVs. This is like the location of the bulb on mechanical TXVs.
- EXVs are **sensitive to dirt.** Follow manufacturers instructions carefully during installation, and ensure there is a clean filter-drier unit upstream of the EXV.
- Stepper valves need to be **reset at regular intervals** to recalibrate the controls. This is best done by powering off the controller with the unit – do not keep the controller powered up permanently.

POSSIBLE POTHOLES 7

Some EXVs only have a **local digital display** – bad for checking operation regularly.

Do not retrofit **pulsing** EXVs to plate heat exchangers! Risk of liquid flood back.

Do not retrofit EXVs as the only action – you have to improve system controls at the same time.



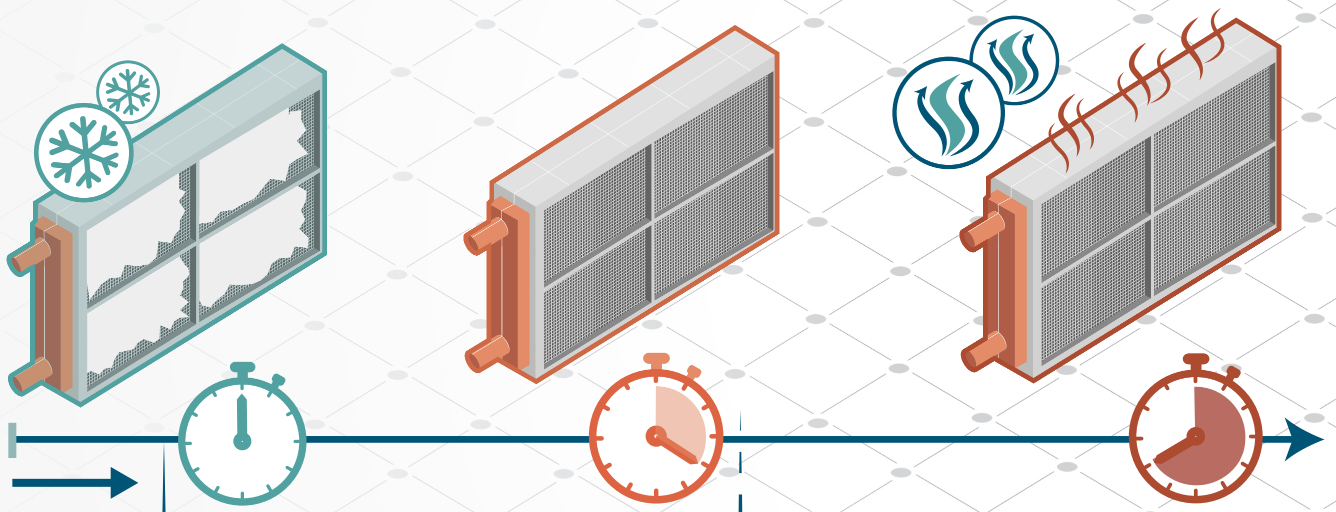
DEFROST OPTIMISATION

① STANDARD PRACTICE

Defrost cycles are usually set to **reoccur after a fixed time span** and to **last for another fixed time span**, irrespective of changed conditions from one day to another.

Fixed frequency and duration of defrost cycles are chosen from **experience** to assure evaporators are always freed from ice and operation is sound on any given day. They might be adjusted for summer and winter operation, but that is it.

Each defrost is the **same**, irrespective of conditions.



Irrespective of ice built-up. Probably defrost **was not yet required** & **could have been delayed.**

not until **fixed time** has passed even if evaporator was ice-free well before.

Excess defrost time **heats up evaporators** & adds unwanted **heat** to cool room.

Excess heat has to be removed & **increases** cooling demand.

Two ways to make defrosts more efficient:

Delay defrost until it is required.

→ Duty counter

Abort defrost as soon as evaporators are free of ice.

→ Defrost termination sensors

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② DEFROST TERMINATION

Install defrost termination **sensors** on evaporators.

▼

Sensors measure temperature of evaporators. Control logic will **terminate defrost cycle** as soon as evaporators begin to heat up, hence are freed from ice.

▼

No excess heat introduced into cool rooms.

ENERGY SAVINGS

TEMPERATURE SENSOR ON EVAPORATOR

DUTY COUNTER ③

If defrost starts after fixed time, this does **not consider how much cooling was done** by the evaporator during that time. The more cooling it does, the more ice builds up. On a weekend or at night when the evaporator is not working as much as during production, **defrosts could be further delayed.**

The solution here is an internal **duty counter** in the control system. By **tracking opening time** of the evaporator's solenoid valve, cooling done by the evaporator can be tracked.

Implement a control logic that tracks solenoid opening time (=cooling duty) and **only start defrost after accumulated opening time** has reached a set limit.

Defrosts are avoided when they are not yet necessary.

Energy savings

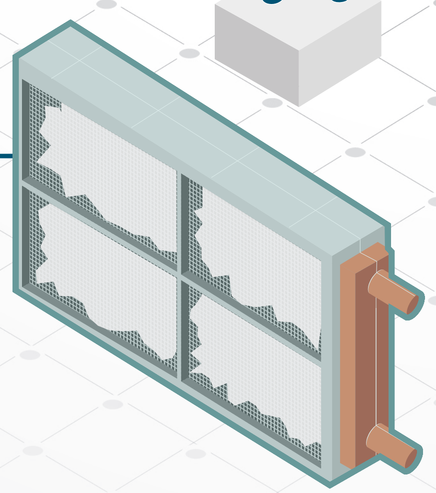
> **It is common sense, wherever defrosts are used, it makes sense to optimise them.**

4 DOES THIS WORK FOR ME?

Do you have evaporators that are **defrosted** with hot gas or electric heaters?

Do you have a **competent PLC programmer** to program duty counters and defrost termination logic into the PLC?

Do you have a **timed** defrost?



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6 GOOD TO KNOW

- Place the defrost termination sensor at the **most heavily iced-up positi-on** on the coil to ensure it is fully defrosted.
- **No more re-adjusting** of defrost settings throughout the year needed
- Some sensors clip onto the **evaporator fins** – this is better than just fixing the sensor to the coil face.
- Sensor location **deep within the coil** is ideal, but difficult to retrofit.
- Ice melts at 0° C – hence a defrost sensor temperature of 5° C = no ice!! **Do not overheat** the coil.

POSSIBLE POTHOLES 7

If you do **carcass reheats**, make sure to implement specific control logic for reheats that **does not terminate hot gas** when evaporators start to warm up, as this is the actual objective in this case.

Important to keep conventional timed defrost **settings as backup**, in case the sensors should fail.

Bad sensor location can cause the sensor to measure air temperature, not coil temperature.

Make sure you can detect **sensor failure** easily or automatically.

SOLAR PV & THERMAL STORAGE

① SOLAR ENERGY

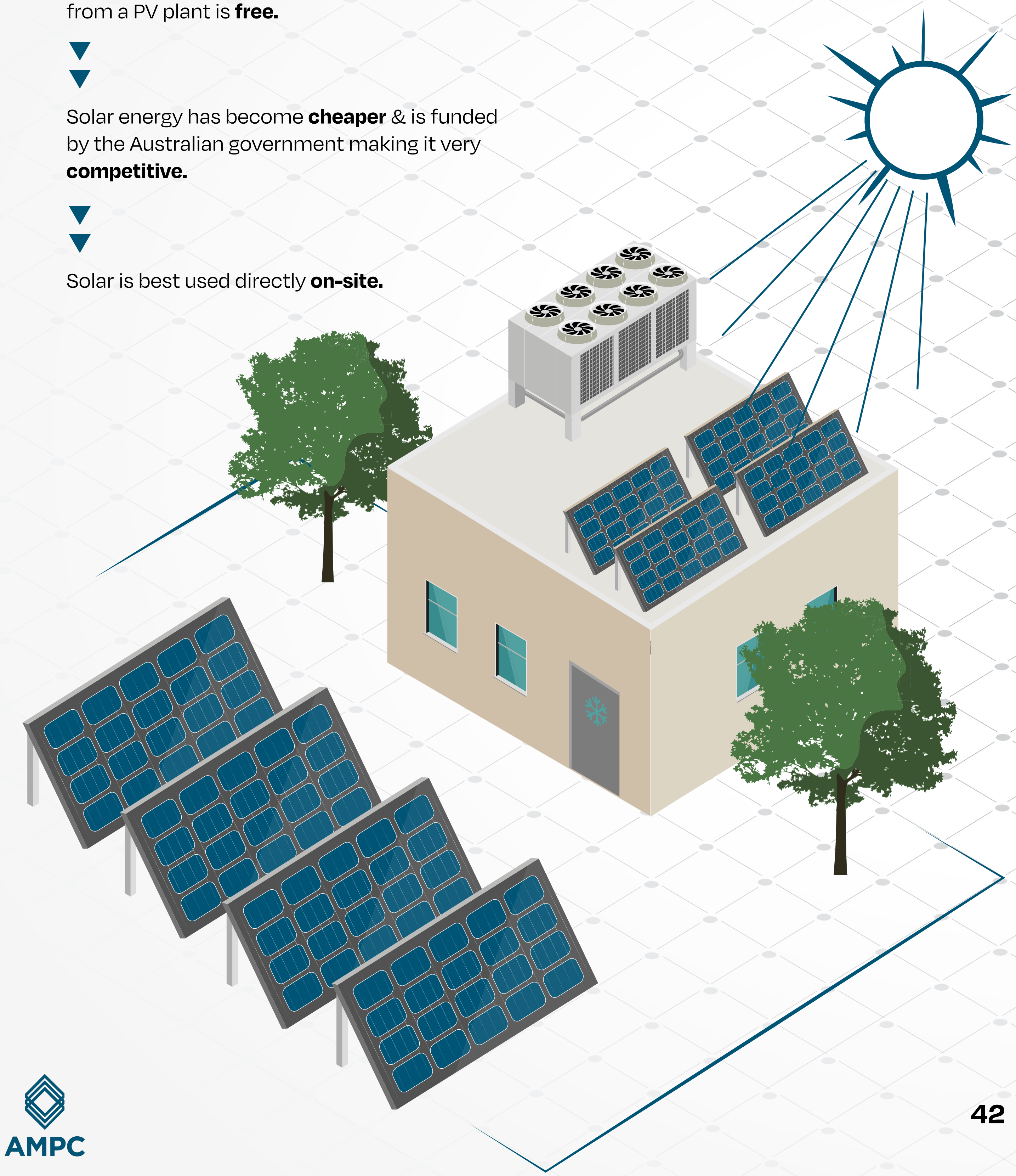
After an **initial investment** into the infrastructure the power generated from a PV plant is **free.**

▼
▼

Solar energy has become **cheaper** & is funded by the Australian government making it very **competitive.**

▼
▼

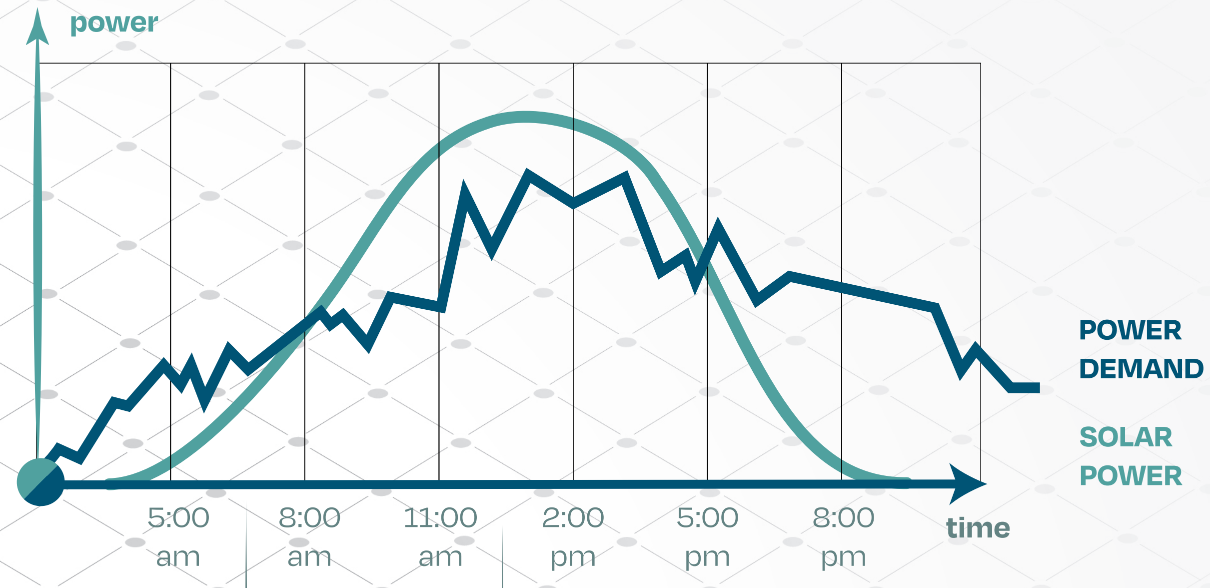
Solar is best used directly **on-site.**



② POWER PROFILES

Usual problem: solar power generation peaks at midday and is low during morning & evening

But abattoir energy usage & solar energy generation **coincide very well.**



PRODUCTION BEGINS

More chillers are **successively** switched on & cooling load builds up.

Cooling demand **declines** as hot carcasses drop in temperature.

First chiller is loaded with warm carcasses and starts cooling.

Killing stops & last chiller starts **(peak demand)** .

A meat processing facility is the perfect fit for solar energy.

Self-generated power is **free**

Money **savings**

Solar energy is **sustainable**

Social license

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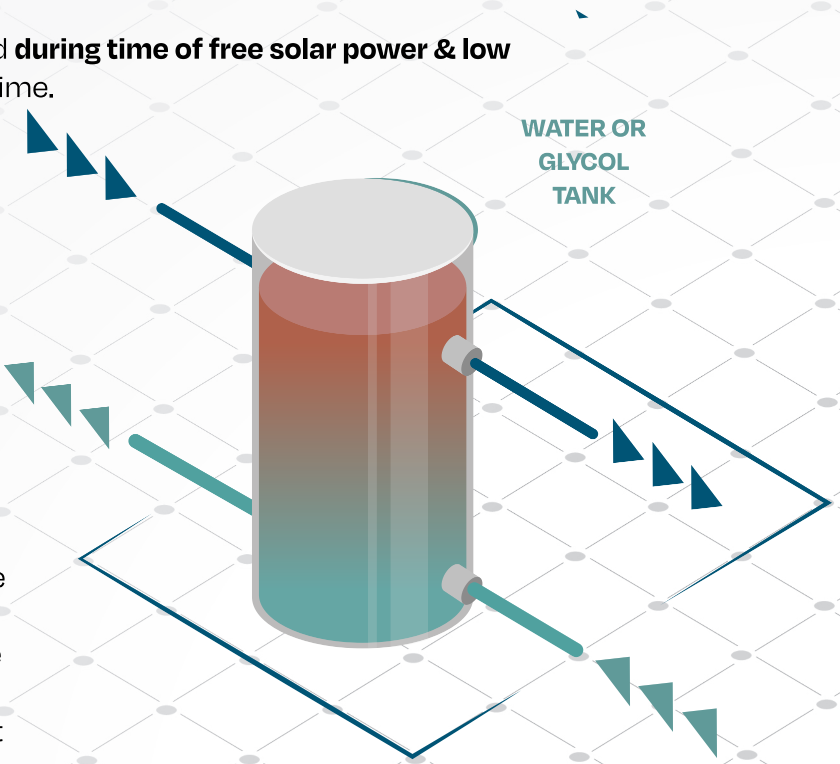
③ THERMAL STORAGE

Run your freezer storage extra hard **during time of free solar power & low energy costs** in your tarif at night time.

By pulling down the temperature of the stored meat (e.g. from -20 to -25° C) **you store cold inside of it**. Then during times of high energy cost you allow your storage to warm up without leaving the warranted temperature range.

If you have **a glycol system** use use an insulated tank as a thermal storage. Pull down the tank's temperature **at times of excess solar & low energy costs** at night!

Same goes for a **hot water tank**, if you have a **heat pump**



DOES THIS WORK FOR ME? ④

CHECKLIST

- Is there **unused accessible roofspace** on site?
- Do you have **high electricity rates**?
- Do i process animals during **typical daytime shifts**?
- Do you have **high electricity rates?**

If you answer these questions with yes, the solar PV is likely to be a good fit.

Excess solar power and cheap off-peak power make storages compelling.

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⑤ GOOD TO KNOW

- Rather than owning the panels, **a solar PPA** (power purchase agreement) is a very good option - you do not need to worry about cleaning or hail damage.
- Great solution for **car parks,** if you do not have shade for the employee's cars.
- Demand management on refrigeration works really well in combination with solar - control the refrigeration so it **matches solar output.**

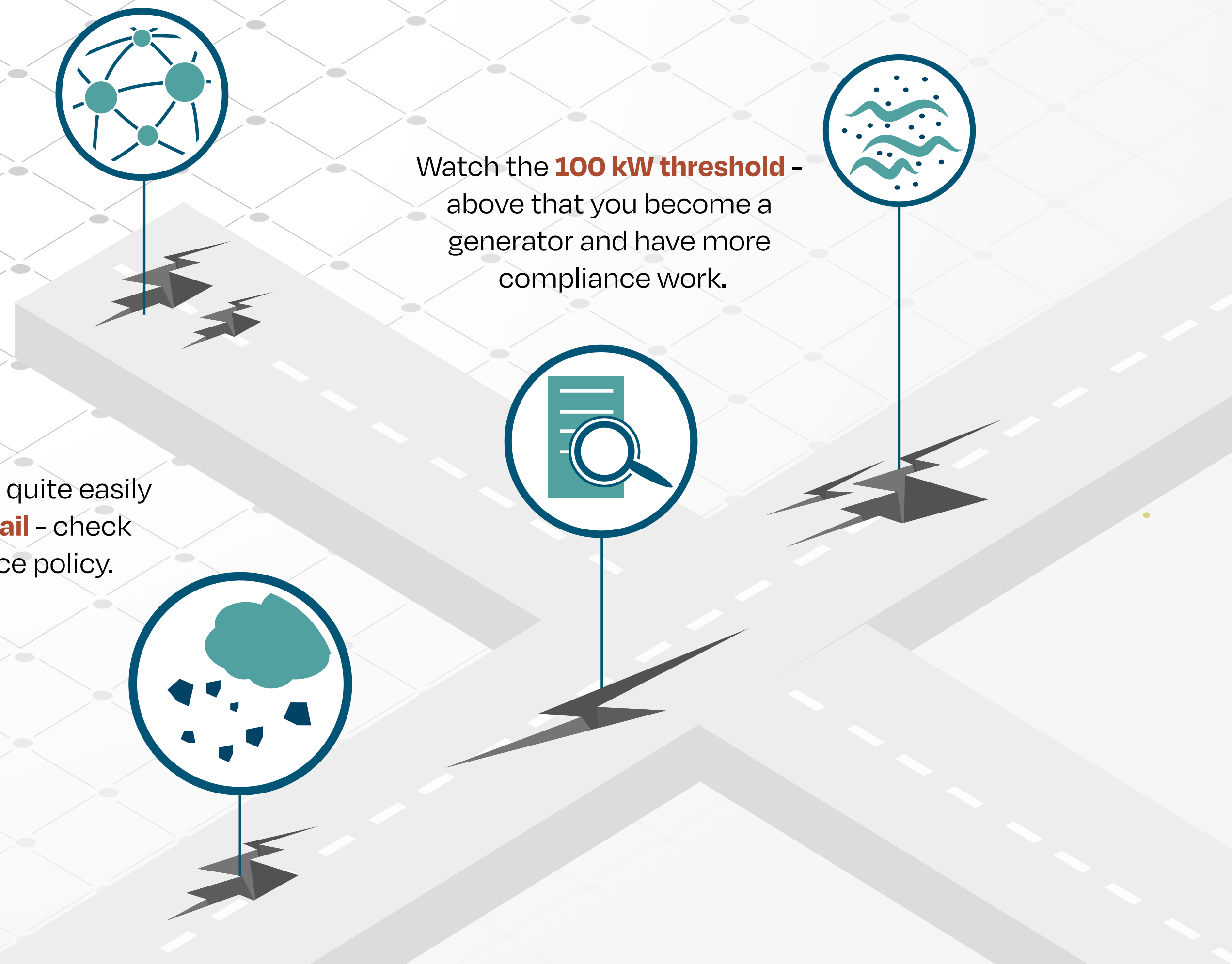
POSSIBLE POTHOLES ⑥

Oversizing installed PV can backfire as **many areas dont pay** for or even allow feeding **into the grid.**

Solar PV maintenance can be high in very **dusty environments**, e.g. near ploughed fields.

Watch the **100 kW threshold** - above that you become a generator and have more compliance work.

Solar panels are quite easily damaged by **hail** - check your insurance policy.



PLANT REPLACEMENT TO CO_2 AND/OR NH_3

NATURAL REFRIGERANTS ①

CARBON-DIOXIDE

AMMONIA

Occur in nature & are **bio-degradable** hence the name.

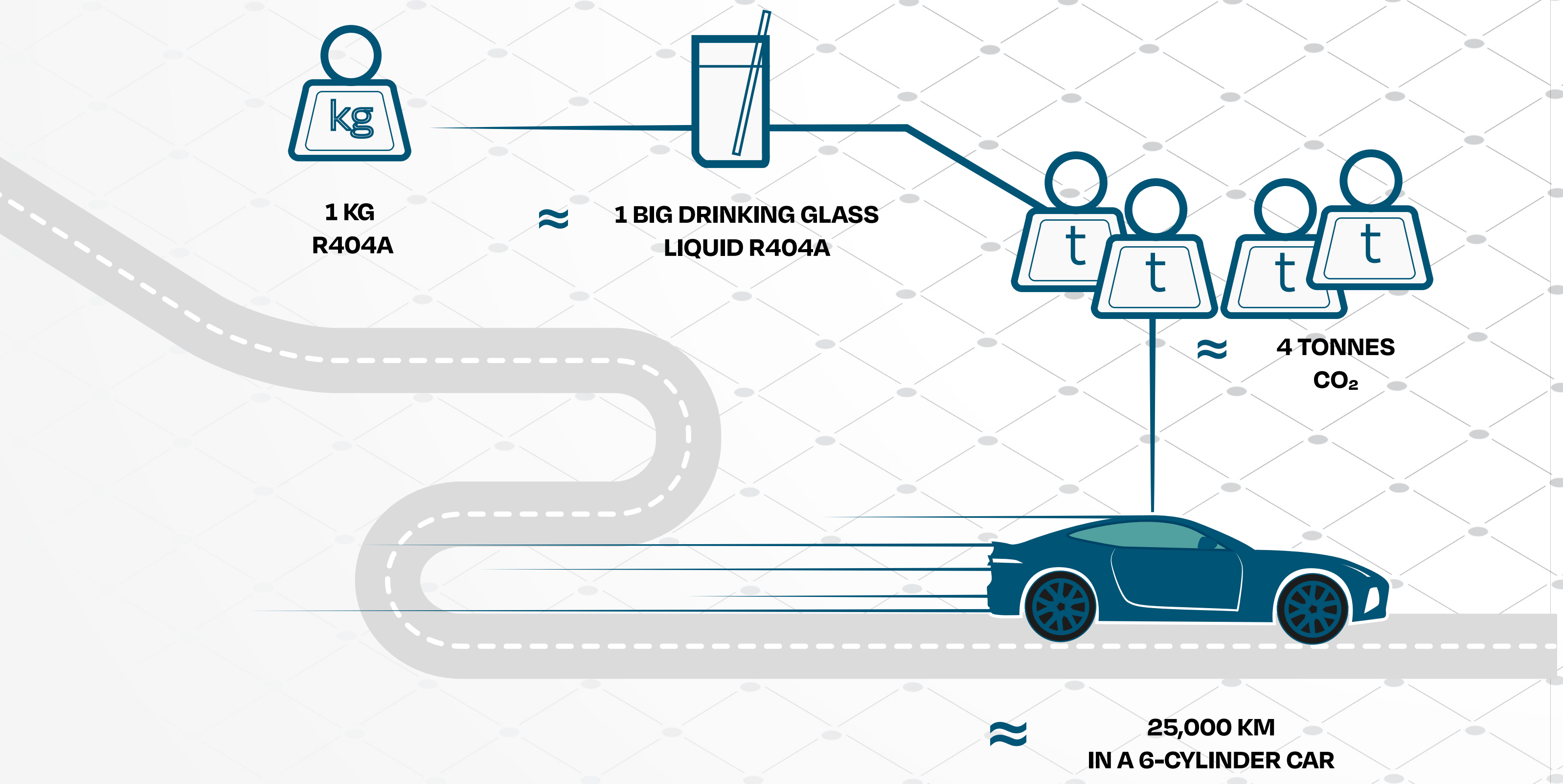
Government mandated **phase-down of freon refrigerants** like R404a.

▼

Freon refrigerants will become more expensive & finally be **unavailable.**

▼

Opportunity for energy efficiency! Natural refrigerant systems are more energy efficient and future-proof. The phasedown does not compel you to replace the systems, but it makes it less viable to keep them



Refrigeration systems might have a ton of R404a in them with leakages of up to 20 % per year!

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② CO_2 OR NH_3?

NH_3 IS **TOXIC**

New technologies make NH_3 (R717) suitable even **for small applications** and **very safe.**

Highly energy efficient & widely used in meat industry.

Great heat recovery opportunities, espcially for **wash-down water.**

Capital costs at the beginning are **substantial,** therefore use for site expansion/larger applications.

CO_2 (R744) is already widely used **for all refrigeration applications.**

Safe
Effectively non-toxic, not flammable.

Very efficient
Low running costs, electricity & fuel savings.

CO_2 is outstanding for generating hot water at the same time, even to very high temperatures suitable **for sterilisation.**

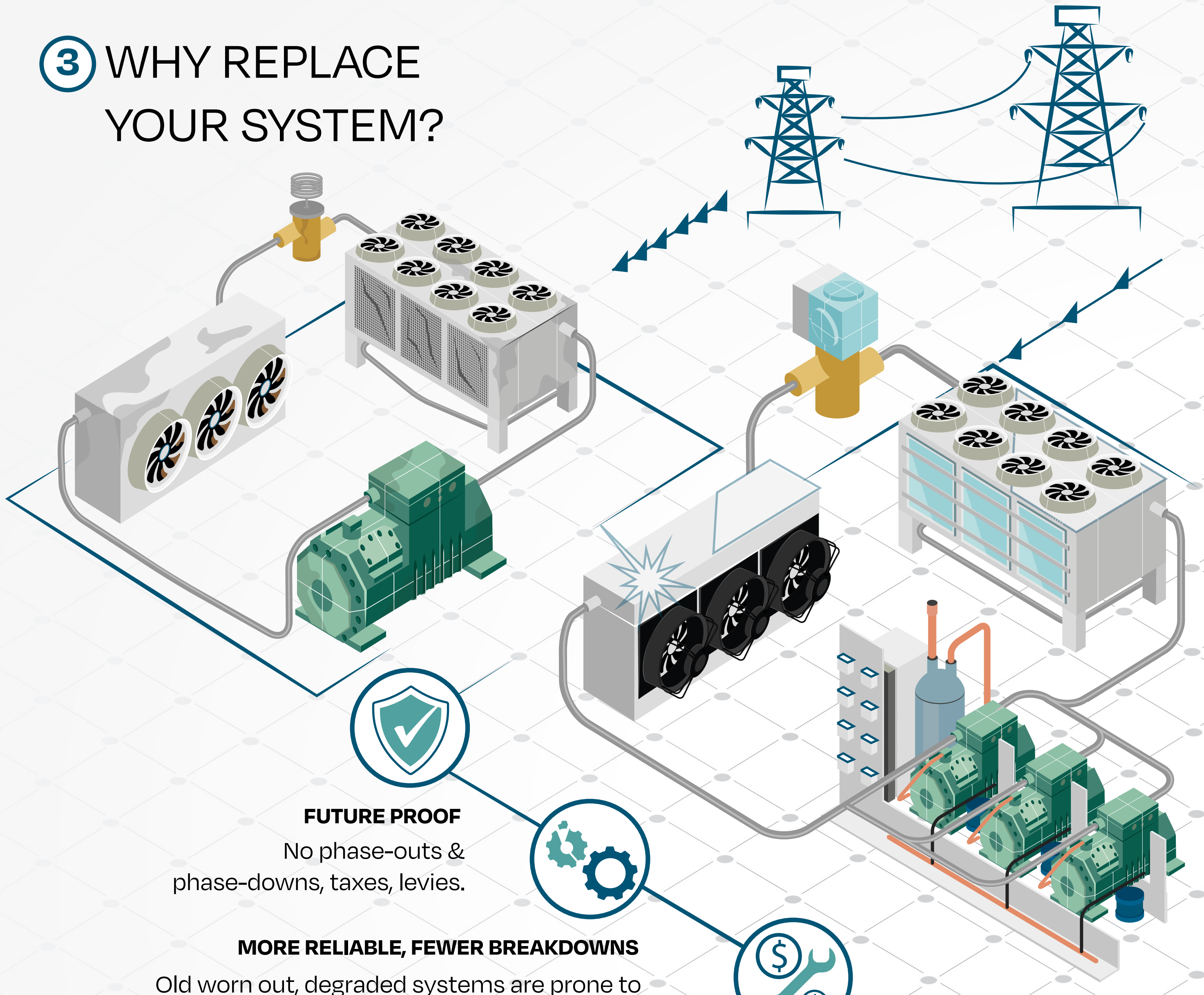
A CO_2 system that also generates hot water is the **cheapest solution available** (no need for boiler).

Compact & light
Cheaper building structure.

FYI: If you want to learn more about modern NH_3 and CO_2 systems, check out the New Technology Handbook.

NEW TECHNOLOGY HANDBOOK

3 WHY REPLACE YOUR SYSTEM?



FUTURE PROOF
No phase-outs & phase-downs, taxes, levies.

MORE RELIABLE, FEWER BREAKDOWNS
Old worn out, degraded systems are prone to outages.

REDUCE RUNNING/MAINTENANCE COST
New systems with natural refrigerants are very efficient and need less service.

ENVIRONMENTALLY FRIENDLY

4 DOES THIS WORK FOR ME?

1. Do you have a **freon** refrigeration system?
2. Is all or part of it **more than 8-10 years** old?
3. Is your boiler old and near end of life? Is it only used for wash-down & sterilisation (no rendering)?
4. Does the site use LPG or diesel for heating?

If the answer to **1) and 2)** is yes, then a **central natural refrigerant system** may be a great option, and if the **3) or 4)** is yes, then a **natural refrigerant system** may be your cheapest option.

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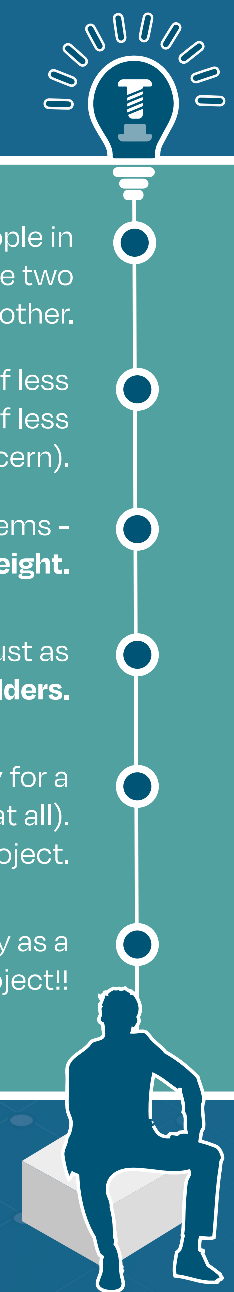
5 GOOD TO KNOW



Due to toxicity NH_3 cannot be used directly in rooms with many people in them like the boning room and requires a **glycol circuit** to separate the two from each other.

Due to the high pressures in CO_2 systems pressure **losses** are of less concern & **longer piping** is possible (should still be avoided but of less concern).

CO_2 systems have much smaller pipe sizes than ammonia of freon systems - makes them **easy to retrofit and lightweight.**

New copper-alloy pipe material make installing CO_2 systems just as easy as freon systems - **no need for welders.**

If you have an old boiler that needs replacing, this is an opportunity for a CO_2 system as you may end up with **a much smaller boiler** (or none at all). This helps with justifying the upgrade project.

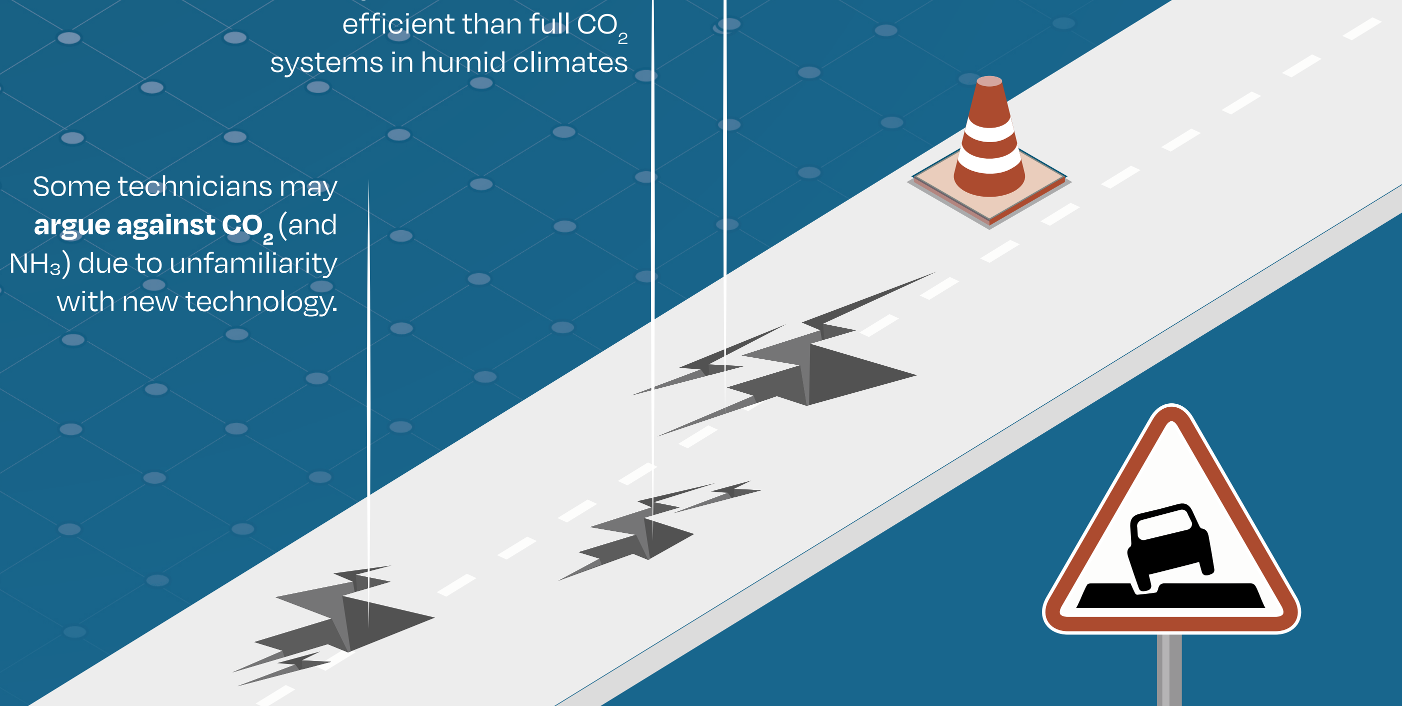
Full CO_2 systems can also generate chilled water very efficiently as a by-product - very handy for **adding office air-conditioning** to the project!!

6 POSSIBLE POTHOLES

Full CO_2 and low-charge CH_3 systems are competing alternatives - this is often not a simple choice!

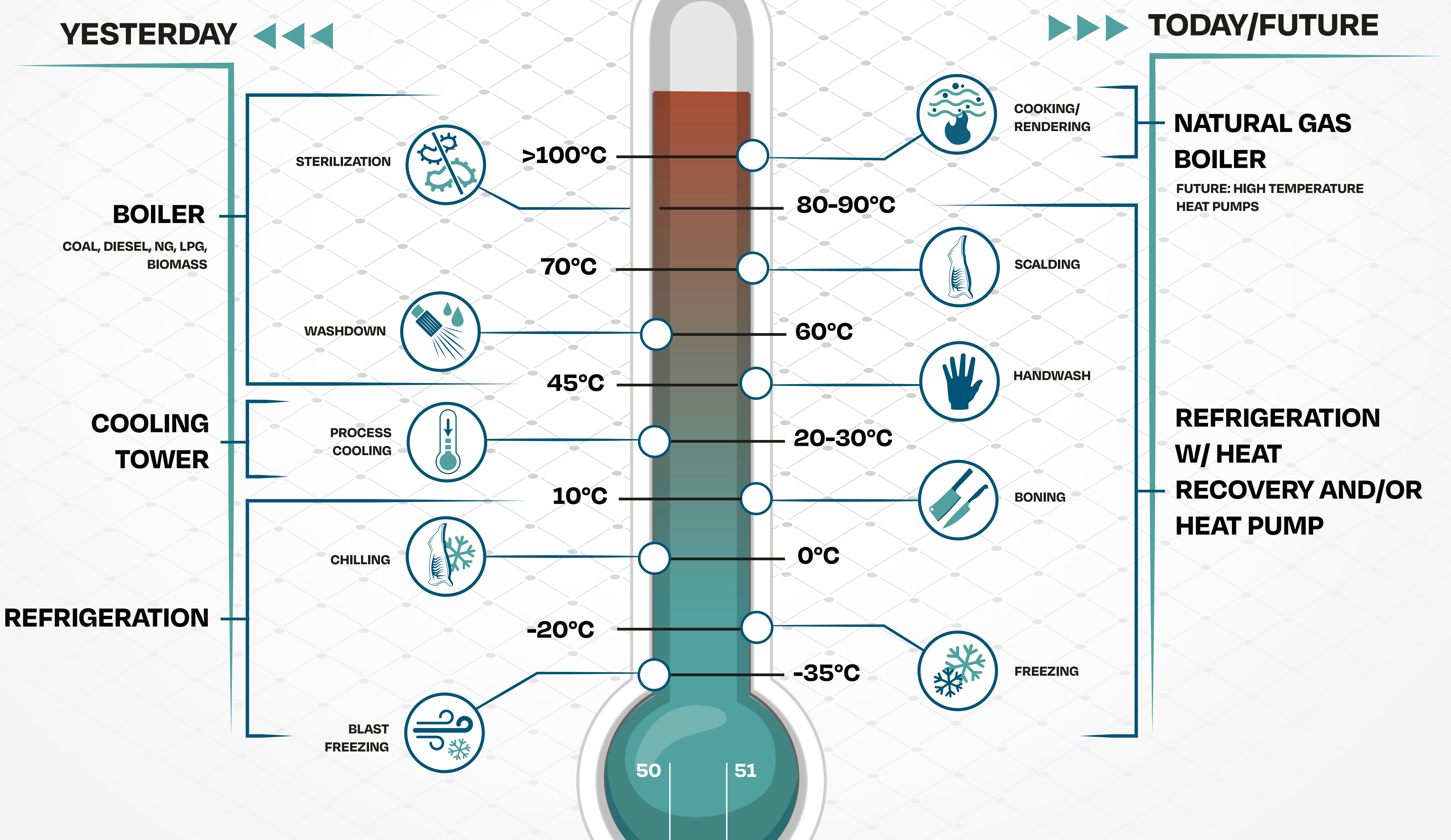
Low charge ammonia systems will be more efficient than full CO_2 systems in humid climates

Some technicians may **argue against CO_2** (and NH_3) due to unfamiliarity with new technology.



TEMPERATURE NEEDS IN AN ABATTOIR

This graphic shows the different **process temperatures** inside an abattoir. Up until now cooling and heating were provided by **two different systems.** Most cooling is done by the **refrigeration plant** while heat comes from **boilers.** Incentivised by **higher fuel costs** and the need to **lower CO_2 emissions** most **heating needs can be covered by the refrigeration plant through integration.** At this moment in time only **steam for rendering** must still be provided by a boilers, but **high temperature heat pumps** could relieve them in the near future.



HEAT RECOVERY

FOR WASHDOWN WITH UPGRADED PLANT

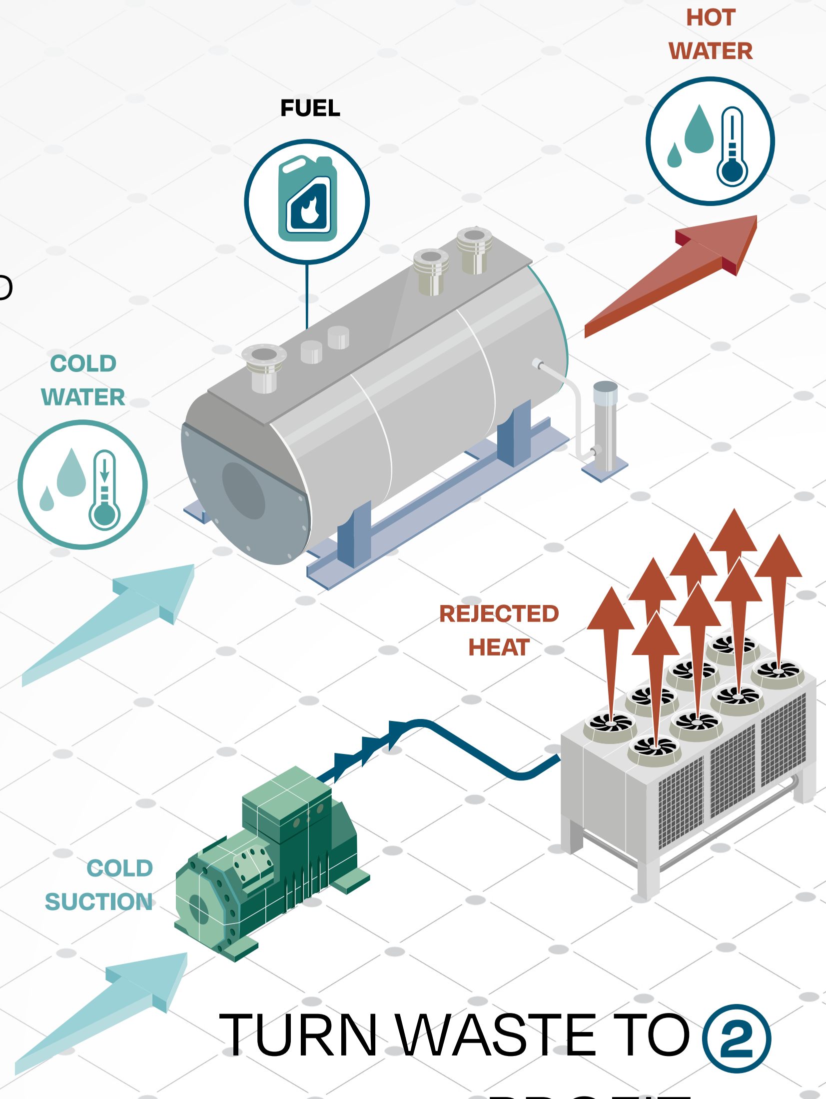
① STANDARD PRACTICE

Until now: freon refrigerants have **low discharge temperatures**. this is bad for heat recovery.

▼

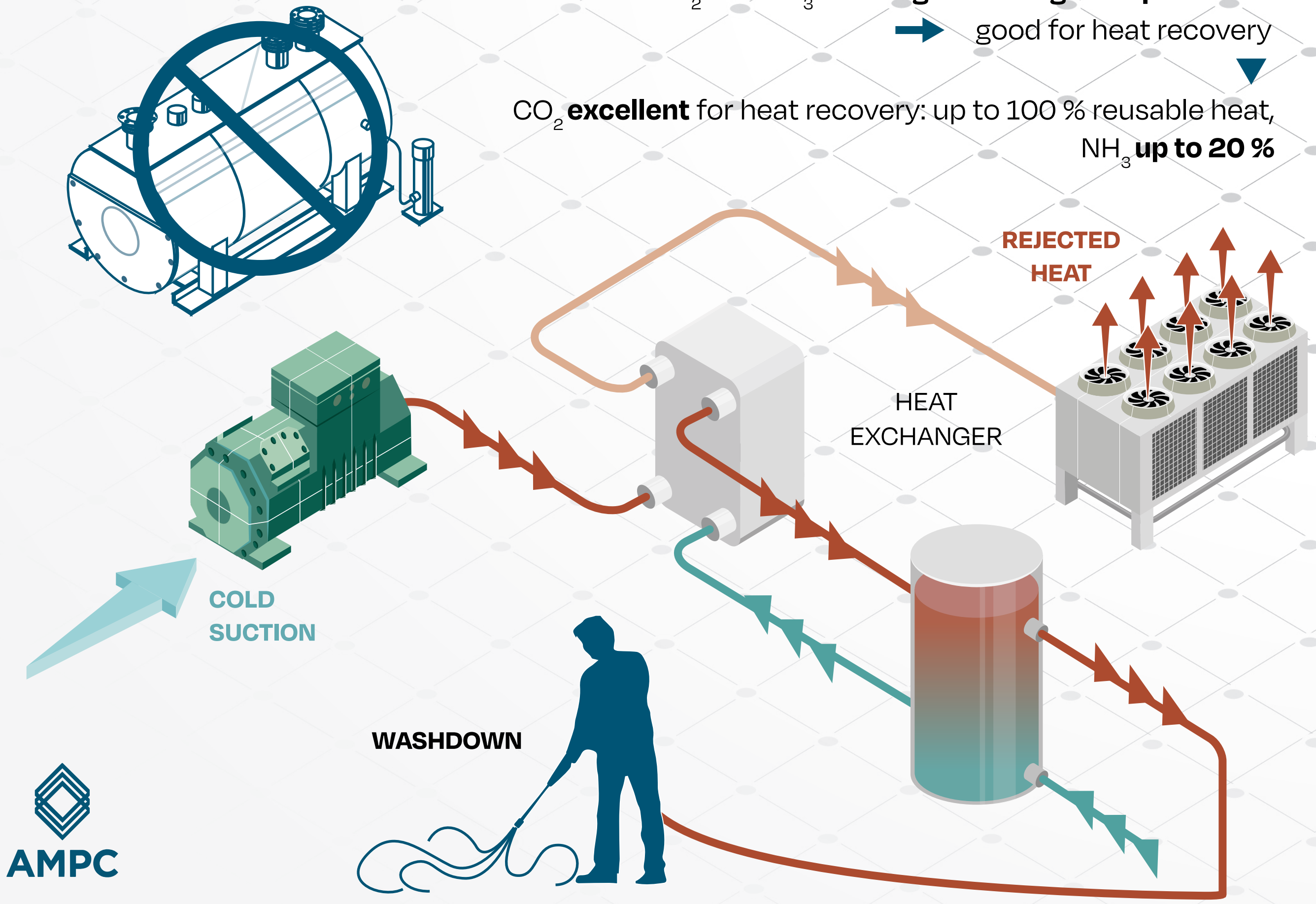
Heat of hot discharge is completely rejected by condenser without being put to use. Meanwhile a boiler generates hot water by burning fuel.

→ **INEFFICIENT**



TURN WASTE TO PROFIT ②

CO_2 and NH_3 have **high discharge temperatures**
→ good for heat recovery
▼
CO_2 **excellent** for heat recovery: up to 100 % reusable heat, NH_3 **up to 20 %**



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③ DOES THIS WORK FOR ME?

CHECKLIST

- Do you need **hot water** to wash down your processing areas?
- Are you thinking about an upgrade to CO_2 **or** NH_3? Or are you already using any of these?
- Are you using **LPG or even diesel** for heating fuel?
- Is your hot water or steam boiler **inefficient** or due for replacement?

GOOD TO KNOW ④

- With heat recovery stratified storage tanks are steadily **heated up all day.**
- Both ammonia and CO_2 can provide large amounts of **washdown water (60-70 °C).**
- In cool climates, CO_2 systems may be able to generate enough heat **for winter office heating** as well.

⑤ POSSIBLE POTHOLES

Do not store water at <45 °C continuously- **legionella risk!!**

A **fully mixed hot water tank** will reduce heat recovery a lot.

Keep existing boilers as backup for breakdown or service.

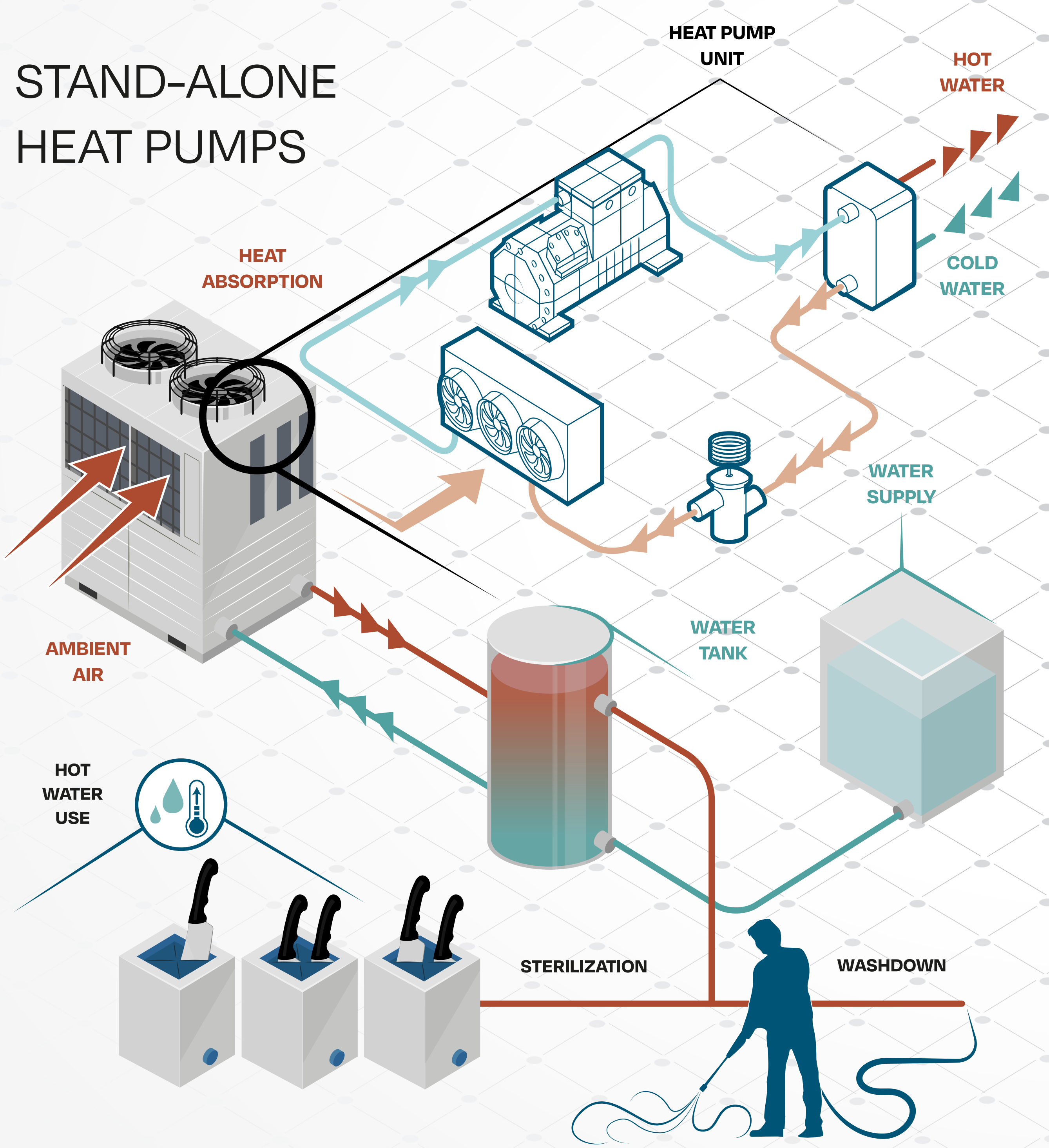
Fit VSDs and good controls to water pumps to control temperatures **even at part load,** otherwise you will lose temperature.

AIR SOURCE HEAT PUMPS

① HOW DOES IT WORK?

An air-source heat pump is **stand-alone** and draws heat from the ambient air.
This allows you to generate hot water at point of use, rather than pump it from a remote plant room. Most air-source heat pumps use CO_2 as refrigerant, but ammonia is also plausible for large units.

② STAND-ALONE HEAT PUMPS



The evaporator of an air source heat pump takes **heat** from the **ambient air.** This allows for small decentralized stand-alone units. These units can be installed at various locations, away from the main plant, directly where the hot water demand is, saving pump power.

A compressor then raises the vapour from the heat pump evaporator to such high pressures that it can heat water to temperatures as high as **95 °C** for **sterilisation** or **60 °C** for **wash down.**

THE BENEFITS ③

High coefficient of performance (COP) & high discharge temperatures result in large amounts of heat at high temperatures by using only **a fraction of that in electricity**

Reduce piping and pumping costs by locating the heat pump close to point of use.

If you have Solar:

Electric power used by heat pumps can be generated by **solar.**

▼

Hot water can easily be stored.

▼

Counteract daytime dependent availabilty of solar power.

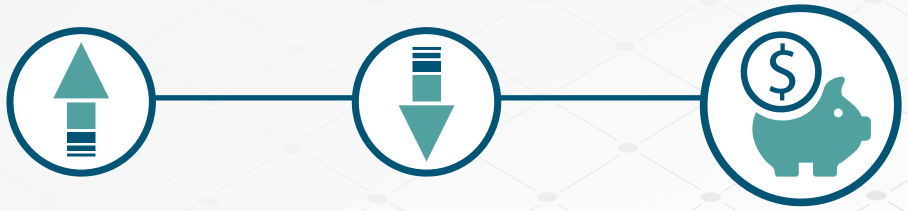
▼

More savings from solar.

③ DOES THIS WORK FOR ME?

- [ ] Are you using **considerable amounts** of hot water to wash down your plant and for sterilizers?
- [ ] Do you spend a lot of money or are **dependent on fuel**?

Fuel costs for wash down and sterilisation hot water can be **completely offset** by heat pumps. In return, electricity costs will rise due to heat pump power consumption. But due to high efficiency of heat pumps their electricity should cost less than the fuel for boilers. The **difference** and therefore the **savings** will depend on your fuel and electricity costs (heat pumps work well with solar).



High fuel prices.

Cheap electricity or solar.

More savings from heat pumps compared to fuel boilers.

- [ ] Is your steam boiler **inefficient or old?**

If an investment for a new boiler is due, this is the perfect time to replace it with a heat pump.

- [ ] Are you **not** rendering on site and run a steam boiler **for knife sterilisation only?**
- [ ] Do you need hot water a long distance from the plant room?

If you do not use steam for rendering, heat pumps allow you to cover all temperature needs of an abattoir without need for a steam boiler.

Also, by generating the hot water close to point of use, less heat is wasted and pumping power consumed.

GOOD TO KNOW 5

- In additionto money savings, heat pumps allow you to lessen your CO_2 footprint by **not burning fuel.**
- **No boiler inspections** required for these heat pumps.
- As these air sourced heat pump units are decentralized stand-alone units, they do not have any effect on the rest of the plant and therefore **no synergies** with other EEOs, which all evolve around the central ammonia plant.

- Both NH_3 and CO_2 heat pumps are capable of producing water to 95 °C, hence good for sterilizing.
- Always use stratified hot water storage tanks – cold at the bottom, hot at the top – and speed controlled pumps to maintain temperatures.
- CO_2 heat pumps work well even under **very cold winter conditions (<<0 °C).**
- Heat pumps can be located **close to** where you **need sterilizer water** - adjacent to the boning room.

POSSIBLE POTHOLES 6

CO_2 heat pumps require a **specialist to repair**

→ Best to manifold several together and have a backup unit on site.

CO_2 heat pumps especially are **not good for "topping up"** hot water as in a ring-main, but need to lift water from low temperature to usable temperature in one go.

Do not oversize heat pumps or size for peak demand, size for average demand and use storage tanks.

This Guidebook is one of five developed during the “Refrigeration Plant Energy Improvement” research project by the Australian Meat Processor Corporation (AMPC). The series aims to help plant personnel and stakeholders of meat processing facilities to identify energy efficiency opportunities within their refrigeration systems.

This Guidebook subtitled "COMMERCIAL FREON SYSTEMS" is aimed at small-sized meat works which use commercial type freon refrigeration systems.

AMPC