

ENGINEERING
TOMORROW



Save energy and protect the environment with our CO₂ solutions

Experience the Danfoss CO₂ expertise in Food Retail, Commercial and Industrial Refrigeration

up to
30%
energy savings
with a suitable CO₂
system compared to
traditional systems
with HFCs.



#1

**in refrigeration
with CO₂**

CO₂ info

In recent years, CO₂ has become an increasingly important refrigerant in a number of applications. Most important to this development, is that from an environmental and safety perspective, CO₂ is one of the few sustainable refrigerants for supermarket systems. However, CO₂ is not a drop-in replacement for all existing refrigerants, and its suitability for each application should be evaluated against TEWI (Total Equivalent Warming Impact) and life-time cost.

Danfoss considers CO₂ to be among the most attractive refrigerants in industrial refrigeration and food retail applications. This is also confirmed by developments seen in the refrigeration market-place. Danfoss offers a variety of products for all CO₂ applications, including subcritical, transcritical, pump-circulated and hybrid systems.

Why CO₂

A sustainable choice

- Environmentally exceptional
- CO₂ does not effect the ozone layer and compared with traditional HFC refrigerants has up to 4000 times less impact on global warming
- A refrigerant that won't be phased out. Therefore no need to worry about pending legislation for HFC reduction and phase out, costly refrigerant management schemes, or increasing refrigerant cost and taxation
- It's the easiest way to shrink your carbon footprint and supermarkets report carbon footprint reductions of more than 30% taking all sources into account such as administration, distribution and lighting, by simply switching to CO₂ refrigeration

An efficient choice

- Superior thermophysical properties
- High volumetric efficiency translates into smaller pipes, insulation and compressors
- High heat transfer efficiency translates into greater capacities with smaller footprints
- Proven savings – End users, both industrial and commercial are beginning to report results. CO₂ reduces operating costs
- Cascade systems with CO₂ provide high efficiency in all climates
- Transcritical systems provide an efficient, simple and cost effective solution in milder climates
- In secondary systems CO₂ will save up to 90% on pumping power vs. traditional brines



Customer benefits

Danfoss offers complete CO₂ system solutions including:

ADAP-KOOL® control and monitoring systems, regulating and injection valves, sensors (temperature, pressure, gas detectors), filter driers and line components.

Danfoss components provide the lowest total cost of ownership, while also reducing the total carbon footprint of supermarket refrigeration systems; both direct and indirect. With the experience from thousands of both transcritical and cascade installations, Danfoss is a reliable partner. All components released for CO₂ have been thoroughly tested to ensure that they can withstand the impact of CO₂. Danfoss can offer support as well as monitoring services for CO₂ systems.

Energy Savings

Energy Savings/environmentally sustainable

As a refrigerant CO₂ has beneficial thermo-physical properties that translate into reduced line losses, smaller dimensions, and supreme heat transfer.

The newest systems take full advantage of the high quality heat rejected from the refrigeration system by recovering it for space and process heating purposes. The new AHR award winning pack controller from Danfoss, is saving retailers 30% on the combined energy required for heating and cooling; extreme operating cost savings!

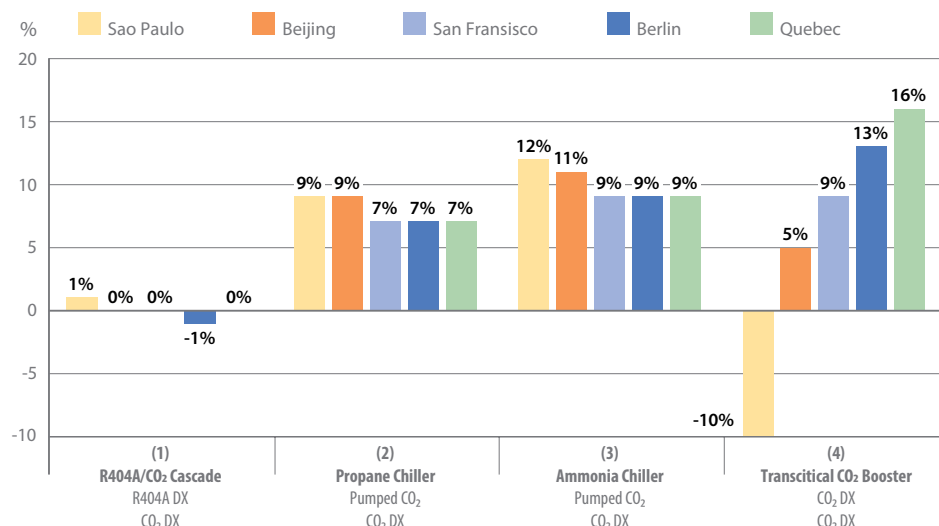
If all supermarkets worldwide were to switch to CO₂, over 50 million tons of CO₂ equivalent emissions could be saved annually.

Expert in CO₂ refrigeration

Danfoss is an experienced and reliable partner

- with over 2500 CO₂ transcritical systems installed globally
- with more than a decade with CO₂ valves in the field
- with 10+ years of extensive experience within CO₂ system design in all areas (control, valves and compressors)

Energy savings compared to state of the industry reference of different configurations using CO₂ as refrigerant in alternate locations around the world



CO₂ Applications and environmental impact

Commercial



Food retail

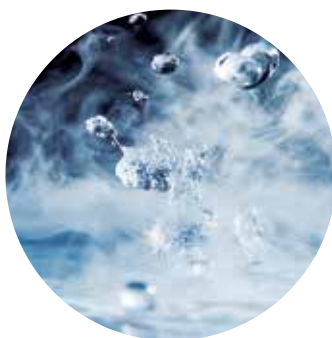
Industrial



Industrial



Transport refrigeration



Heat Pumps



Server and electronic cabinet cooling

Broad application range

Due to factors such as the efficiency, safety, toxicity and global climate impact of a refrigerant, it is clear that no single refrigerant is ideal for every application. Danfoss believes that CO₂ as a refrigerant is beneficial in a broad variety of applications for different reasons. The primary applications where the use of CO₂ can provide most advantage include the following; food retail, industrial, heat pumps, transport refrigeration, server cooling and electronic cabinet cooling. The main reasons for each are listed.

Food retail: The leakage of high GWP (Global Warming Potential) refrigerants from food retail installations make this a natural target for environmental legislation. Non-toxic and non-flammable, CO₂ lends itself well to this segment.

Industrial: CO₂ is extremely efficient as a secondary fluid for medium temperature applications. As a refrigerant it is most efficient at low temperatures. As it also has excellent heat transfer properties and high volumetric efficiency, many products can be frozen in small footprints.

Transport: This is an application where refrigerant leakage rates can cause significant environmental impact. Non-toxic and non-flammable, CO₂ can be applied here to reduce the overall carbon footprint within the sector.

Heat pumps: Where hot water is needed, CO₂ is the perfect solution. Transcritical CO₂ cycles reject a large proportion of the cycle heat at high temperatures. This also makes CO₂ an efficient choice in applications where both heating and cooling is required.

Server and electronic cabinet cooling: Non-flammability and high heat transfer efficiency within small footprints is key when dealing with electronic applications. CO₂ may also be used in free-cooling circuits where minimal power is needed to circulate the media.

Danfoss is joining customers in celebrating the successes of implementing CO₂ systems. The following pages highlight two key applications and just a few of these success stories.



30.000 km

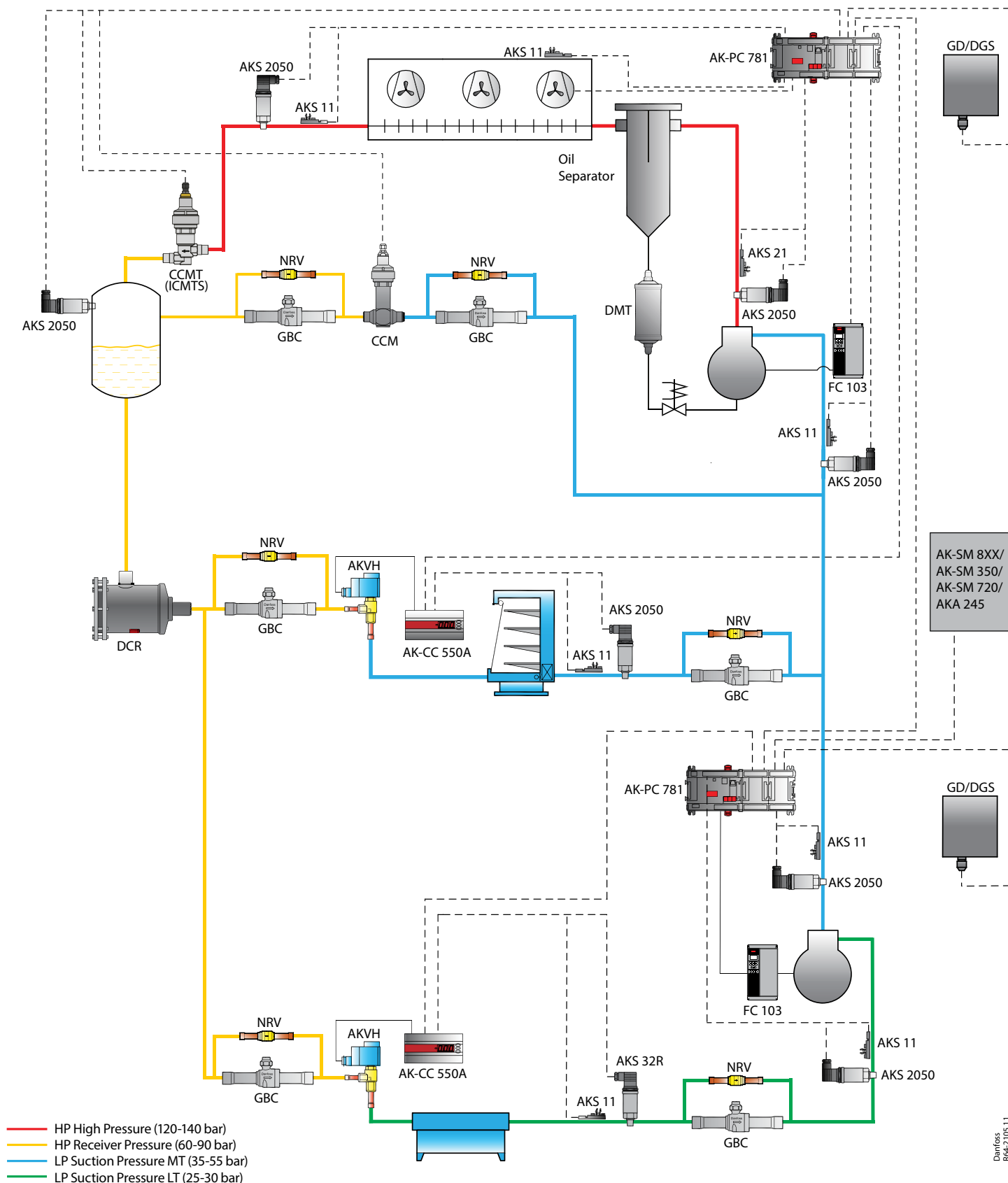
is how far you can
drive a Volkswagen
Golf 2.0 TDI to
emit an amount
of CO₂ equivalent
to leaking 1kg of
R404A.

Food retail transcritical booster system

The transcritical booster system enables high efficient heat reclaim and is one of the most promising systems in cold to mild climate areas. The reason for this is that the energy consumption is on the same level or better than R404A systems

or better and the design is relatively simple. A typical CO₂ transcritical booster system is divided in to three pressure sections; high pressure section, intermediate pressure section and low pressure section.

Controls for a transcritical system can be divided into four groups; gas cooler controls, receiver controls, injection controls and compressor capacity controls.

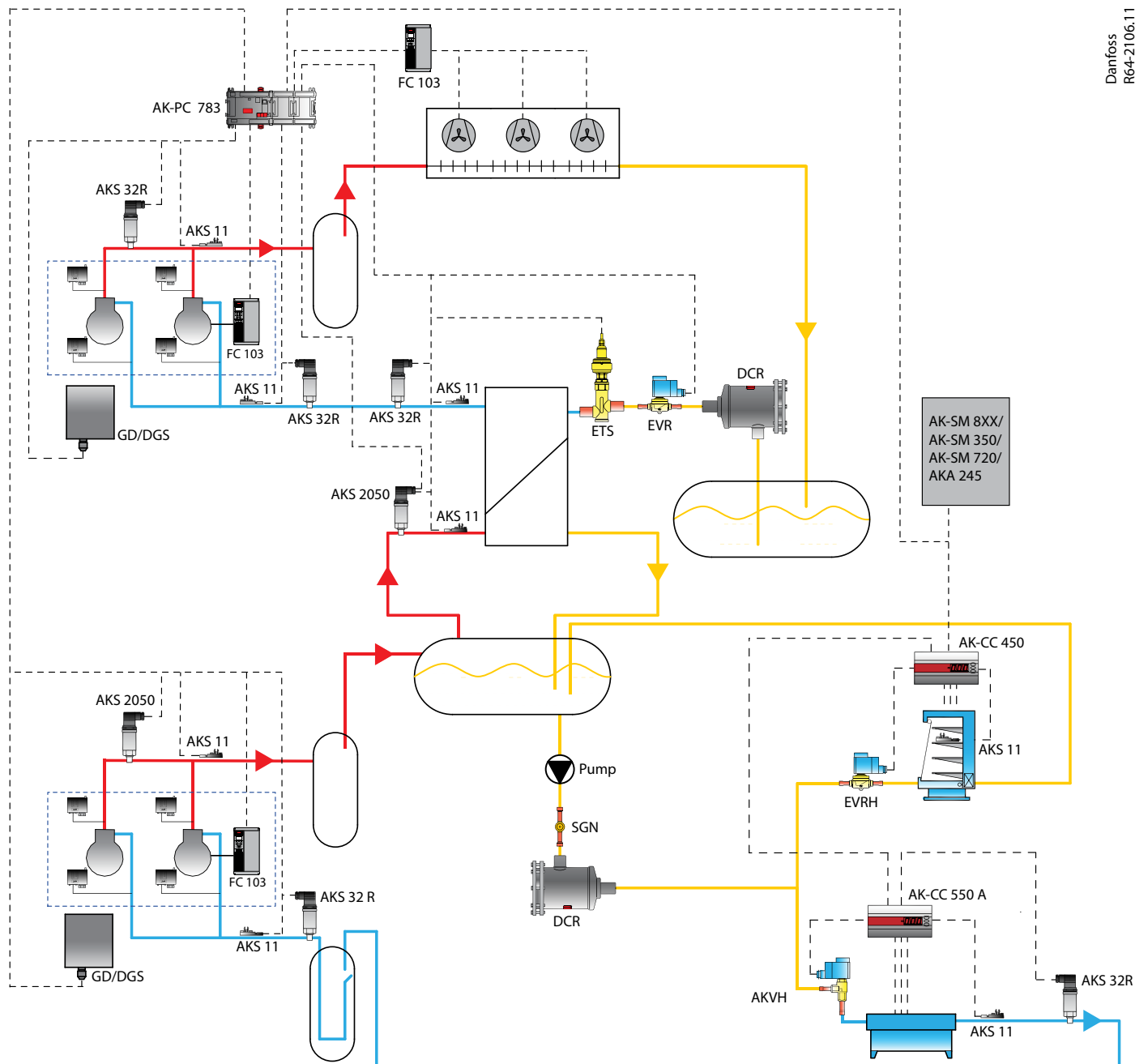


Food retail cascade HC/HFC-CO₂ system

Applying CO₂ in cascade systems gives a number of advantages:

- Efficiency of the system is high even in the hot climates
- Only a small amount of refrigerant is needed for high temperature stage
- Temperature difference for cascade heat exchanger is relatively low
- On the high side various refrigerants can be used e.g. HC/HFC or NH₃

Control of cascade systems can be divided into condenser capacity control, compressor capacity control, cascade injection control, MT evaporator CO₂ flow control and LT evaporator injection control.



Danfoss
R64-2106.11

- HP vapour refrigerant
- HP liquid refrigerant
- LP vapour refrigerant

Industrial refrigeration CO₂ secondary cooling system

Research has shown that installation of a refrigeration system using CO₂ as a fluid is no more expensive than a system installed using a water-based brine/glycol while providing energy savings of up to 20%.

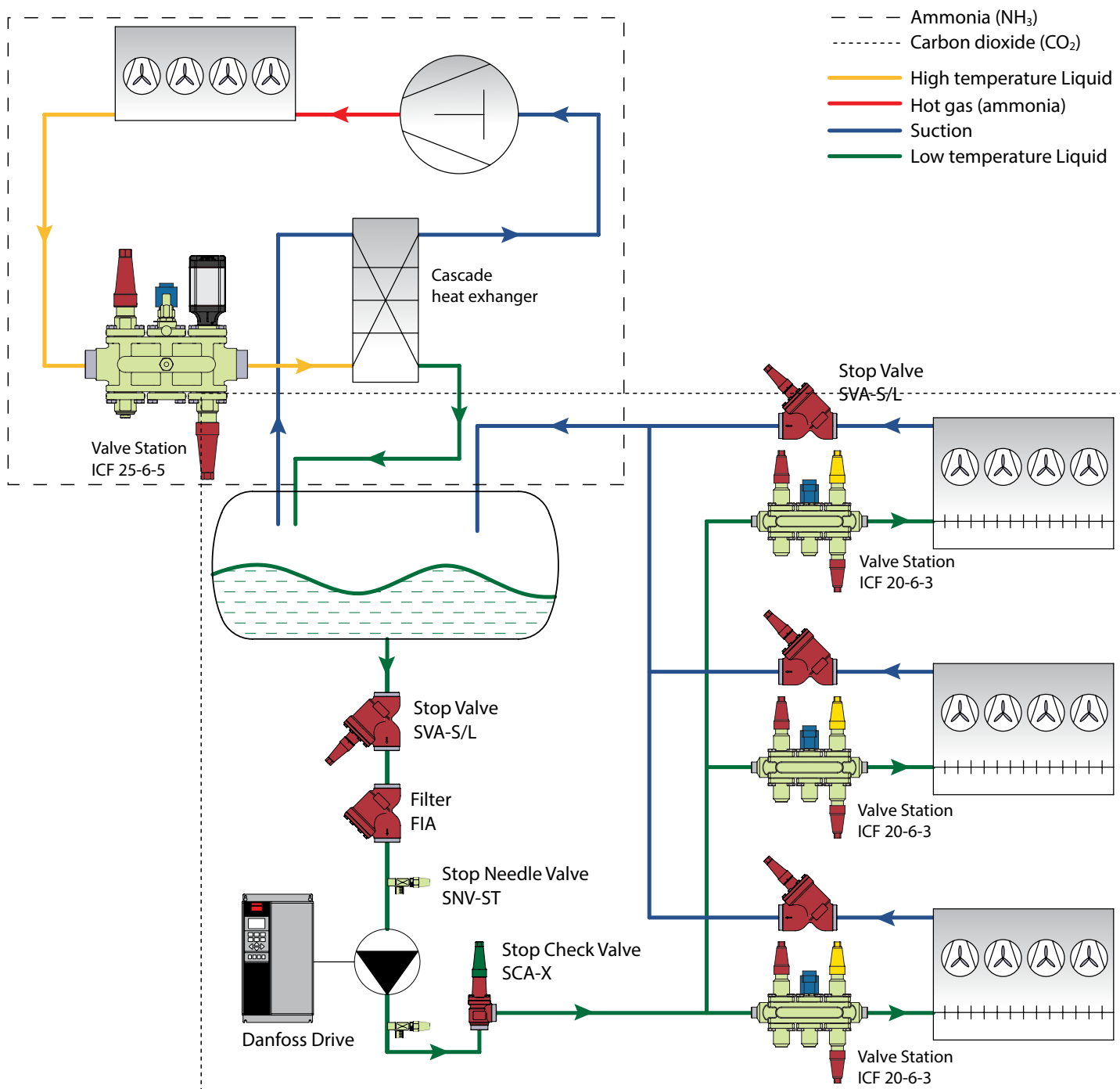
For an experienced installation company it can be cheaper to install a 500 kW

refrigeration installation for cold storage using CO₂ than a water-based secondary cooling system. Examples have shown that savings on the installation can be up to 12%, using a CO₂ based refrigeration system.

Systems using CO₂ as a fluid are relatively simple. The main difference when com-

pared to a water-based brine/glycol system is that the piping and component size on a CO₂ system is considerably smaller for the same capacity.

Visit www.danfoss.com/COtoo and calculate your own savings.



CO₂ myths & facts - how much can you save?

Check out the myths and facts about CO₂ on <http://co2facts.danfoss.com/>

You can find more detailed information about the benefits of using CO₂, and besides the myths and facts you can: calculate your savings, explore which technology is optimal for your system; see different application examples; get an overview of Danfoss CO₂ products for both food retail applications and industrial refrigeration applications; go through cases and learn how Danfoss customers benefit from our extensive CO₂ and refrigeration knowledge; download material covering benefits of using CO₂ as refrigerant.

The CO₂ calculator gives you a very good indication on how much you can save by choosing CO₂ instead of traditional refrigerants in brine systems, cascade systems and transcritical systems. You can also calculate how much you can reduce your carbon footprint.

Our Myths & Facts site makes it easier for you to see the obvious benefits of replacing traditional refrigerants with CO₂.



We kill the CO₂ myths and highlight the facts with concrete examples of the benefits.



In the CO₂ savings calculator you only need to type in three parameters: air temperature, cooling capacity and electricity costs.



Contact us to get a more detailed version of the CO₂ calculator which you can fine-tune to suit your exact conditions.

Contact us at cotoo@danfoss.com



100%

natural

**Optimum
temperature control
and energy efficiency
in ammonia/CO₂
systems.**

Industrial refrigeration – Dual temperature ammonia/CO₂ fluid system

Flanagan Foodservice is a leading distribution service company located in Kitchener, Ontario – Canada. To keep up with growing demand, a new 6,000m² addition doubles the size of the current facility, featuring state-of-the-art CO₂ refrigeration technology, and creating the first facility in Canada to implement this technology.

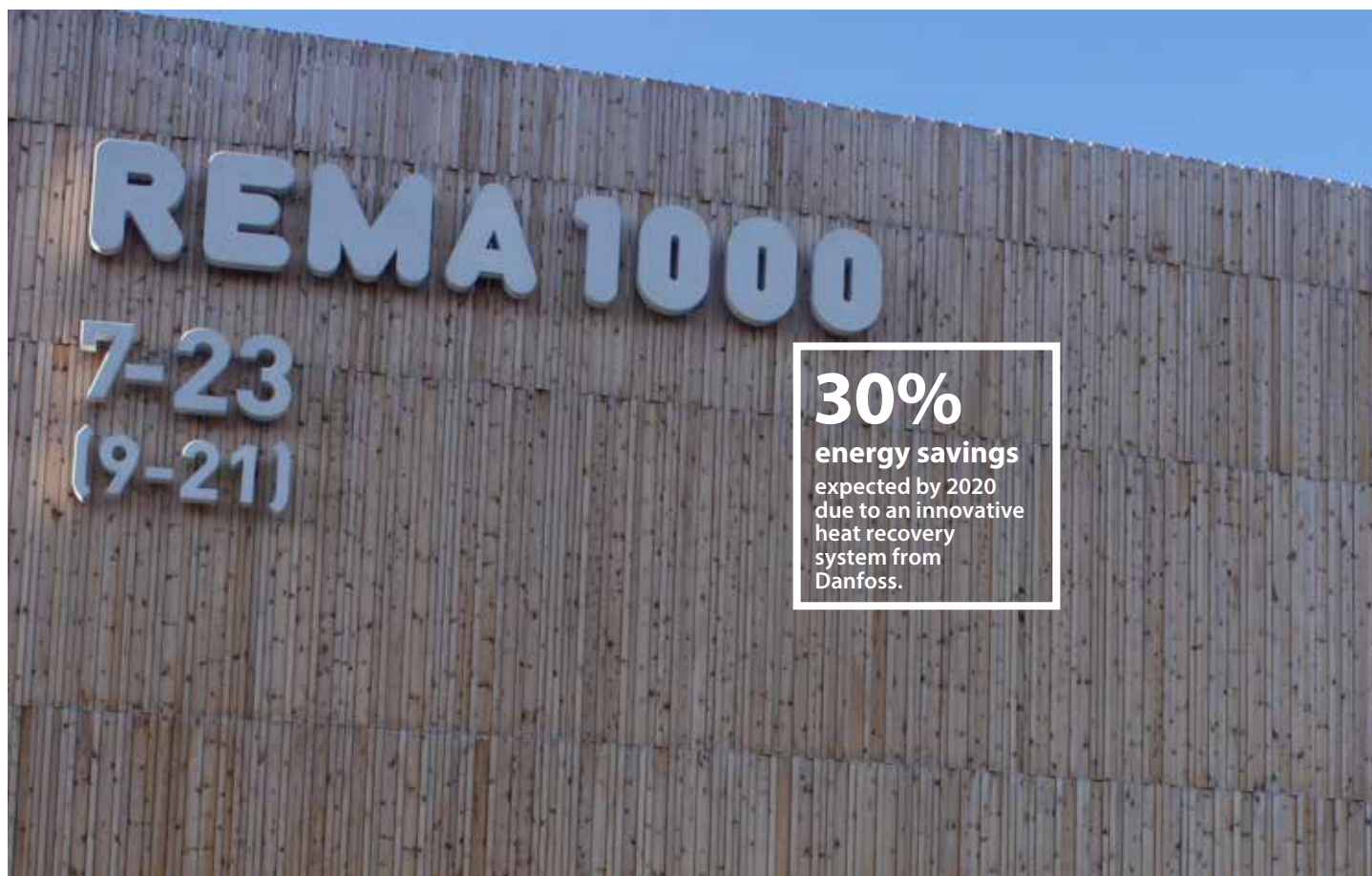
A dual temperature ammonia / CO₂ fluid refrigeration package system refrigerates the 360 kW at –15°C of 4,200 m² of freezer space and 120 kW at –28°C of 450 m² of Ice Cream freezer supplied by Mayekawa Canada.

A cross-divisional effort within Danfoss supplied the well known ICF valve stations feeding CO₂ to the evaporators, flooded shell and tube NH₃ / CO₂ exchangers as well as variable frequency drives and pressure transmitters which run the NH₃ screw compressors and CO₂ pumps. The use of ICM motorized valves in the ICF assembly played a key role in maintaining a stable liquid supply.

The Danfoss frequency converters allow for full balance in the load control of the NH₃ / CO₂ system, meeting the challenges of the flow and the thermal dynamics of CO₂.

Flanagan describes the project as “exciting”, as innovative technology will help to drive the performance of the plant. The system utilises only natural refrigerants; ammonia and carbon dioxide that have minimal (0 and 1, respectively) global warming potential. Besides that, it is more energy efficient than corresponding systems using traditional fluids like propylene glycol.





100% Green supermarket based on CO₂

The REMA 1000 supermarket in Trondheim in Norway looks like a regular supermarket but then the resemblance stops: the store features green grass on the roof, air curtains at the entrance, four 170 meter-deep energy wells, and special panels mounted on the outside of the building to capture the most efficient use of natural light within the building.

The store is 100% green and equipped with an innovative solution from Danfoss that will help the store obtain energy savings of 30%.

A brand new heat recovery system based on CO₂ secures that the staff is enjoying a comfortable working environment and satisfied employees in turn benefit customers.

The AK-SM 850, the new smart front-end controller by Danfoss, secures full energy control of the total store:

“For the first time in the history of refrigeration, we have implemented a 100% green heat recovery solution, and it is based on Danfoss know-how and controllers from Danfoss Electronic Controllers and Services. It is an extremely high-tech and integrated

CO₂ and heat recovery solution where the refrigeration system also serves as a heat pump in winter and provides cooling for the air handling unit in the summer. The surplus heat from the refrigeration system is applied for floor heating, heating up the supply air of the ventilation unit and keeping the pavements snow-and ice-free during the cold Norwegian winters,” Dr. and Senior Research Scientist, Armin Hafner from SINTEF Energy Research, says.

“The team from Danfoss has done a great job. They are effective and constructive, and everyone who sees the store is impressed by the efforts and the high quality,” Armin Hafner concludes.

Facts about the solution

- Danfoss has collaborated closely with SINTEF Energy Research, the Norwegian government, and supermarket chain REMA 1000 to provide 30% energy reduction in Norwegian supermarkets by 2020
- The store makes considerable use of floor heating, ventilation, air conditioning, snow melting and storage of thermal energy
- The solution combines refrigeration and heat pump functions, as well as the control of the air handling unit and the various heat storage devices
- Energy wells of 170 meters depth have been used to obtain free cooling during the summer and as a heat source for the heat pump in the winter
- The building solution features a new light function with special panels mounted on the outside of the building instead of windows, to obtain efficient use of natural light within the building
- The AK-SM 850, the new smart front-end controller by Danfoss, secures full energy control of the total store



Cutting CO₂ emissions into the atmosphere with Danfoss solutions

Alcampo, a Spanish supermarket chain, has reduced the environmental impact of its refrigeration installations after deciding to install an R134a/CO₂ food retail cascade refrigeration system with support from Danfoss in its new hypermarket in Toledo.

Alcampo wished to cut the CO₂ emissions into the atmosphere and Danfoss was a natural partner with experience from thousands of subcritical and transcritical installations around the world. From the outset, Danfoss took part in designing the solution. Cascade R134a/CO₂ system was chosen as the best fit.

- R134a cools the refrigerated services (refrigerator cabinets and cold storage rooms), expanding directly via AKV electronic valves.

- In the same way, the CO₂ cools the freezer services (freezer units and walk-in freezers), expanding directly via AKV electronic valves. R134a is used to condense the CO₂ with an exchanger in which the expansion is carried out directly via ETS electronic valves.

"CO₂ refrigeration systems provide an optimum solution to the challenges of reducing our carbon footprint and increasing energy efficiency, which form part of the Alcampo environmental responsibility pledge", states Antonio Chicón, Alcampo Director of CSR and External Communication, adding, "whilst the system is very similar to a traditional refrigeration system, it would also appear that it is just as easy to maintain".

Danfoss has supplied ADAP-KOOL®

components to Alcampo's new system. The AK-PC series controllers and AKD variable speed drives control the two central refrigeration units, and the AK-CC series controllers govern the AKV electronic expansion valves for both the refrigeration (R134a) and freezing (CO₂) services.

Danfoss CO₂ product range

Product Grouping	Product	Product Description
Transcritical expansion valves	ICMTS	Motorized transcritical control valves
	CCMT	Electrically operated high pressure expansion valves
Pressure regulating & gas-bypass valves	ICS with CVP-HP/XP	Mechanical backpressure regulators
	CCM/CCMT	Standstill capable electronic backpressure regulators
Electronic expansion valves	AKVH	Standstill capable pulse width modulating expansion valves
	AKV	Pulse width modulating expansion valves
	AKVA	Industrial pulse width modulating expansion valves
	ICM	Industrial motorized expansion valves
	CCM/CCMT	Standstill capable motorized expansion valves
Valve stations	ICF	Industrial valve stations
Solenoid valves	EVR 2-8	Small solenoids
	EVRH 10-40	Large solenoids
	EVRS	Industrial solenoids
	EVRST	Industrial solenoids capable of opening at 0 differential
	EVUL	Standstill capable NC solenoid valves
	ICLX	Industrial solenoid valves, one - or two step, on/off
	ICS + EVM	Industrial solenoid valves for large capacities
Shut-off valves	SVA-S and SVA-L	Flexline™ stop valves
	GBC	Ball valves
Check valves	SCA-X and CHV-X	Flexline™ check valves
	NRV	Check valves
Gauge valves	SNV-ST and SNV-SS	Industrial stop needle valves
Sight Glasses	SGP	Sight glasses - solder, flare and socket versions
Filter & Driers	DCRH	Exchangeable core filter driers
	DML	Liquid line filter driers
	DMT	Transcritical oil and refrigerant driers
	FIA	Flexline™ filters
Regulating valves	REG-SA and REG-SB	Flexline™ regulating valves
Liquid level controls	AKS 4100	Liquid level transducers
	EKC 347	PI controllers
Safety valves	SFA 15	Safety relief valves
	DSV	Industrial double safety relief valve manifolds
Pressure switches	RT	Differential pressure switches
	KP 6	Pressure switches
Pressure sensors	AKS 2050	Radiometric transcritical pressure transmitters
	AKS 32	Pressure transmitters (0-5V signal)
	AKS 32R	Radiometric pressure transmitters
	AKS 33	Pressure transmitters (4-20mA signal)
Temperature sensors	AKS 11	Suction side sensors
	AKS 21A	Discharge side sensors
Gas detection	GD/DGS	Gas detectors
Electronic HP controls	EKC326A	Controllers for transcritical operation and gas bypass
Electronic evaporator controllers	AK-CC 450	CO ₂ "brine" case controllers
	AK-CC 550A	Single case controllers
	AK-CC 750	Multi-case controllers
Cascade HX controllers	EKC 313	X-refrigerant/CO ₂ cascade heat exchanger controllers
	EKC 326A	Transcritical controllers
Pack controllers	AK-PC 772	Transcritical pack controller (up to 5 compressors), 3 MT 2 LT, TC control
	AK-PC 781	Transcritical pack controller (up to 8 compressors), integrated TC control
	AK-PC 783	Cascade pack controller (up to 8 compressors), 5 MT 3 LT
System manager	AK-SC 255/355	CO ₂ supermarket system manager
	AK-SM 850	CO ₂ supermarket system manager
Service tool	AK-ST500	Service technician software
Variable frequency drives	FC 103	Compressor, pump and fan motor drives

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information
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danfoss.com/co2**