Recuperación de calor para un sistema que utiliza CO_2 como refrigerante natural

Heat recovery for system with CO_2 as natural refrigerant

Enviromental safe

Energy efficiency

Cost effectiveness

Natural choice

Regulations and restrictions in the different countries

There are several national and international programs that regulate refrigerants, one of those being the European F-gas regulation, which was passed in 2006.

The F-gas rule significantly reduces the amount of fluorocarbons that are sold in the European Union (EU) by dramatically phasing them down.

Facts:

- **As a result of the Kigali amendment more and more countries are stepping up legislative efforts to limit the use of HFCs (China, India, and other developing country).**
- **Upcoming Montreal Protocol meetings will determine funding guidelines for developing countries;**
- **USA - how HFCs will be treated remains to be seen**
- **California will advance its legislation nevertheless - scientific assessment of possible measures currently ongoing**
- **Canada Implementing HFC phase down until 2030 and introduced national carbon tax.**
- **New F-gas law introduced in Japan**
- **New f-gas legislation introduced in Australia amending the Ozone Protection and Synthetic Greenhouse Gas Management (OPSGGM) Act by adding an HFC phase-down plan**

Comparative assessment of refrigerants

Refrigerant designation	R134A	R513A	R1234ze	R448A	R290	R717	R744
Family	HFC	HFO blend	HFO	HFO blend	HC	Natural	Natural
Safety group	A1	A1	A2L	A1	A3	B2L	A1
GWP	1430	573	7	1273	3	0	1
Application	MT	MT	MT	MT/LT	MT/LT	MT/LT	MT/LT
Temp. glyde	0	0	0	**6,2**	0	0	0

Conclusion:

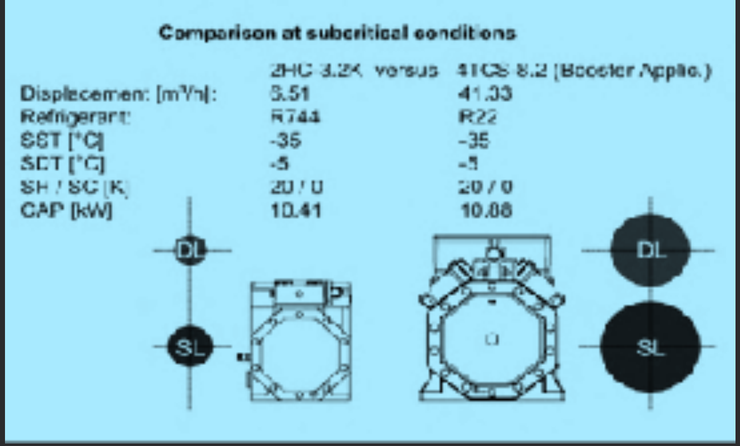
due to specific properties and behaviour regarding:

- Cooling capacity, pressure levels, application limits
- TEWI (COP & GWP)
- Safety classification and requirements, material compatibility

NO SINGLE REFRIGERANT IS IDEAL FOR ALL THE APPLICATION

Why use CO_2 as a refrigerant?

of R744 make it a relatively safe gas & useful refrigerant:



- and at the same time, inexpensive to produce
- s, non-toxic and naturally occurring in the surroundings
- lowest level)
- als (non corrosive)
- Hig mpared with R134a @-10°C) and high evaporating enthalphy (125% of R134a -10°C) à the g en velocity of vapour and liquid phase is lower compare to HFC's. More heat energy is require te liquid CO2 (liquid sloughing).
- ow viscosity in s lines (small pressure losses)
- heat tra s and High thermal conductivity

operate with 2K higher evaporating temperature Vs. HFC

operate with small approach on gas cooler and PHE

CO refrigeration capacity (6 times higher than R404A) resulting smaller

co nd pipe work.

Why use CO_2 as a refrigerant?

Critical point (+31°C ; 73,6 bar)

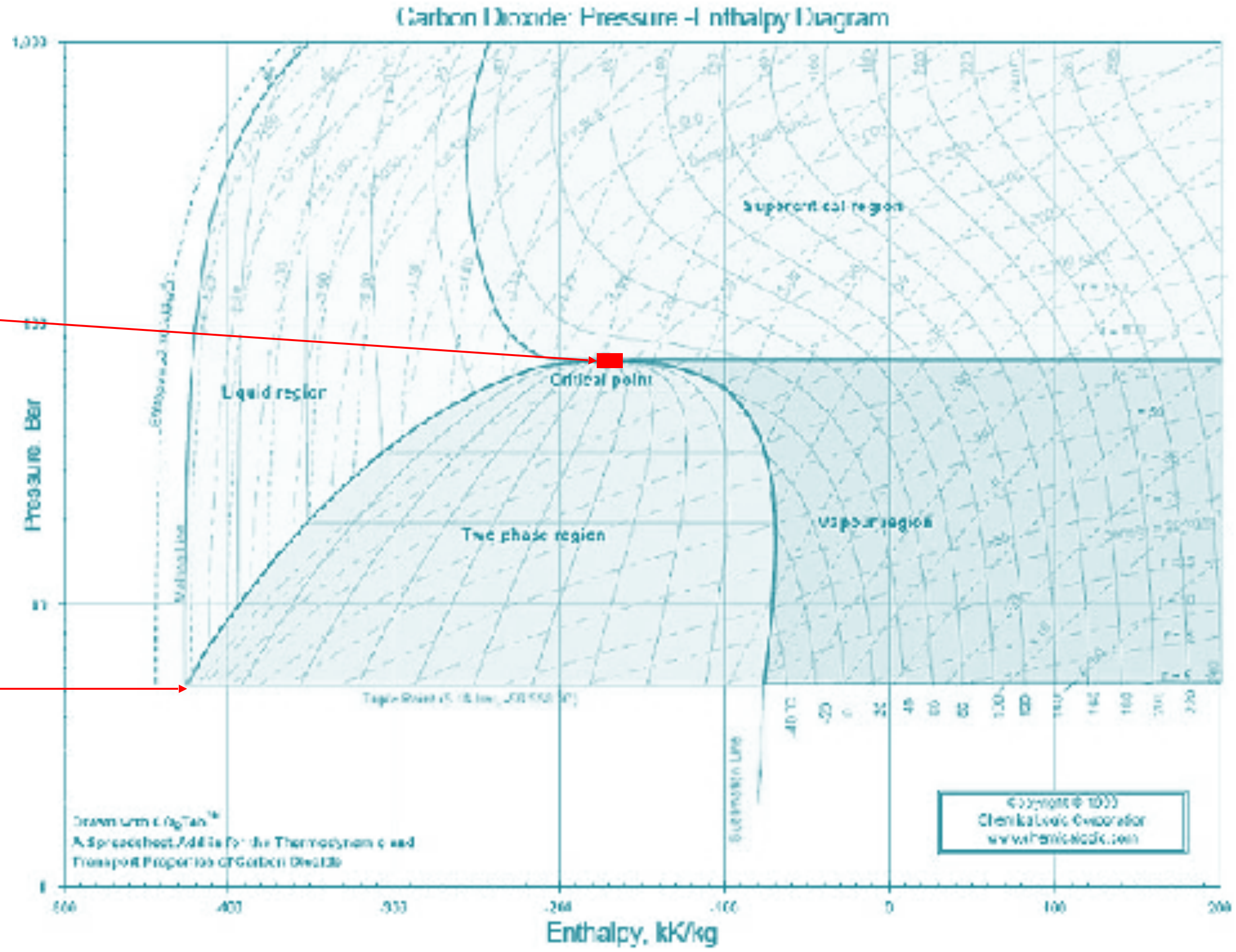
The critical point occurs at the upper limit of the pressure curve. This marks the limit for heat transfer processes based on condensation or evaporation.

At temperatures higher than those at the critical point, no clear distinction can be drawn between what is called liquid and what is called vapour.

From the critical point there is a region extending indefinitely upwards and indefinitely to the right. This region is called the supercritical fluid region.

Triple point (-56,6 °C; 5,2 bara)

The triple point represent an application limit in refrigeration, because below that point liquid is turn into solid



Why use CO_2 as a refrigerant?

REFRIGERANT	R134a	**R404A**	R717	**R744**
Natural Substance	NO	**NO**	YES	**YES**
Ozone Depletion Potential (ODP)	0	**0**	0	**0**
Global Warming Potential (GWP)	1300	**3780**	0	**1**
Critical Point	40.7Bar 101.2ºC	**37.3Bar** **72ºC**	113Bar 132.1ºC	**73.6 Bar** **31.1ºC**
Triple Point	-103ºC	**-100ºC**	-77.7ºC	**-56.6ºC** **(5.2 Bar)**
Flammable or Explosive	NO	**NO**	YES	**NO**
Toxic	NO	**NO**	YES	**NO**

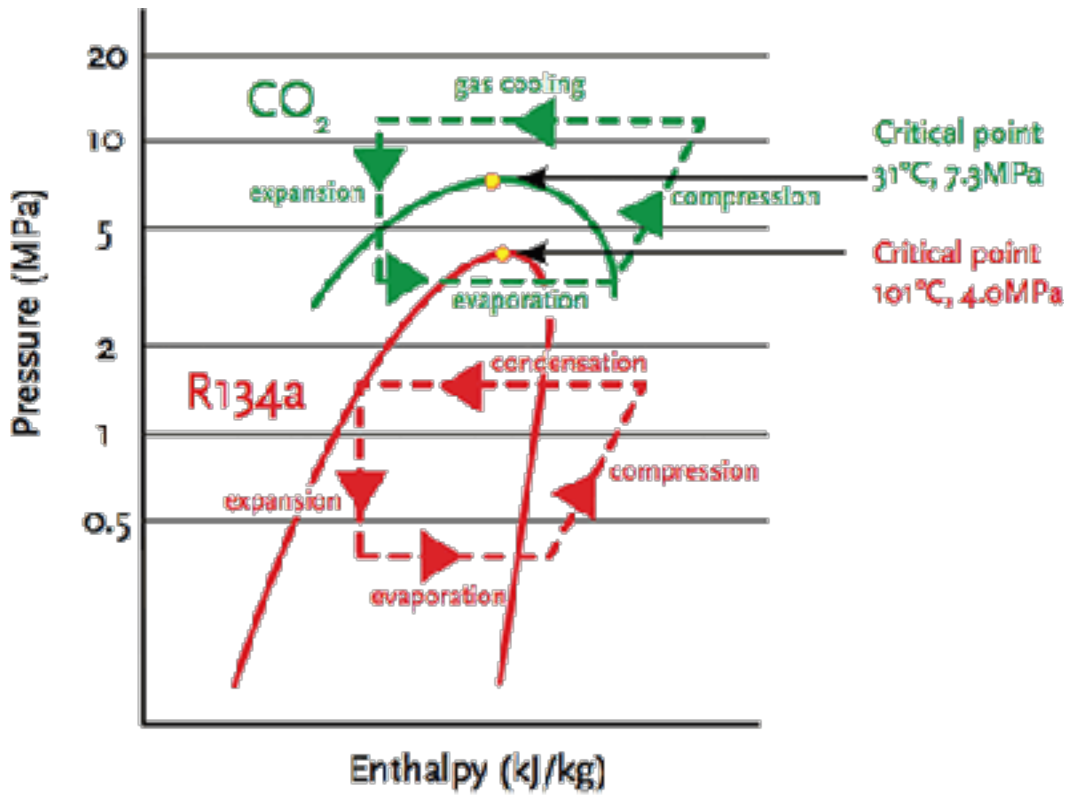
CO_2 Transcritical Cycle

CO_2 Transcritical Cycle

Even if the basic cycle could be consider the same, the application of CO_2 require particular attention due to the different position of the cycle in the p-h diagram.

We can define:
Subcritical cycle the one that is realized completely below the critical point in the diagram (typical of HFC, Ammonia or CO2 cascade)

Transcritical or super –critical cycle when the heat removal from the cycle is realized above the critical point. In that area we cannot call it condensation but Gas Cooling.



Heat Recovery

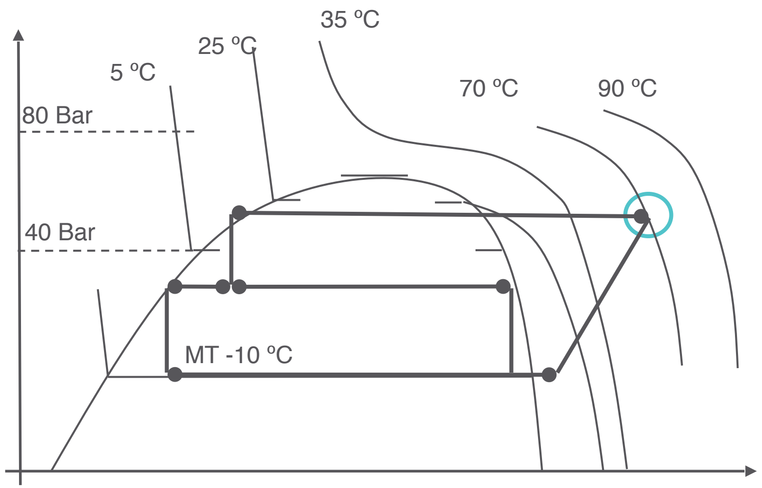
Heat reclaim with CO_2

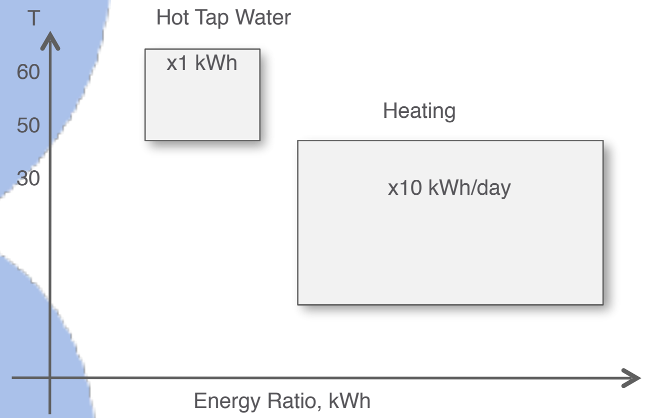
Demand for Heat Reclaim becomes more and more relevant due to rising energy costs.

High discharge temperatures for CO2 compression cycle is normal, often > 70 ºC

This provide hot tap water (typically around 60 ºC)

And low temperature heating for floor heating, radiators, air unit heater, etc.





The Heat ratio is often x10 between hot tap water and heating

Heat reclaim with CO_2

COP DEFINITIONS AND MEASUREMENTS

There are different Coefficient of Performance definitions in a CO_2 system with more evaporator temperatures. In the case of a CO_2 trans-critical booster system (two stage system with bypass) the following definitions are applicable

$$COP_{LT} = \frac{Q_{LT}}{W_{LT} + f_{LT} W_{MT}} \quad (2); \quad COP_{MT} = \frac{Q_{MT}}{f_{MT} W_{MT}} \quad (3); \quad COP_{cool} = \frac{Q_{LT} + Q_{MT}}{W_{LT} + W_{MT}} \quad (4)$$

where COP_{LT} is the COP of the low temperature part of the system (freezing cabinets), COP_{MT} is the COP of the refrigeration part of the system (refrigeration cabinets), Q_{LT} is the Cooling power in the Low temperature cycle ; W_{LT} is the compressor power in the low temp.cycle, f_{LT} is the fraction W_{LT} / (W_{LT} + W_{MT}), Q_{MT} is the Cooling power in the refrigeration cycle ; W_{MT} is the compressor power in the refrigeration cycle, f_{MT} is the fraction W_{MT} / (W_{LT} + W_{MT}). COP_{Cool} is the Cooling COP for the total system. If the heating side is partly or entirely accounted as usable Energy the Coefficient of System Performance COSP is calculated as

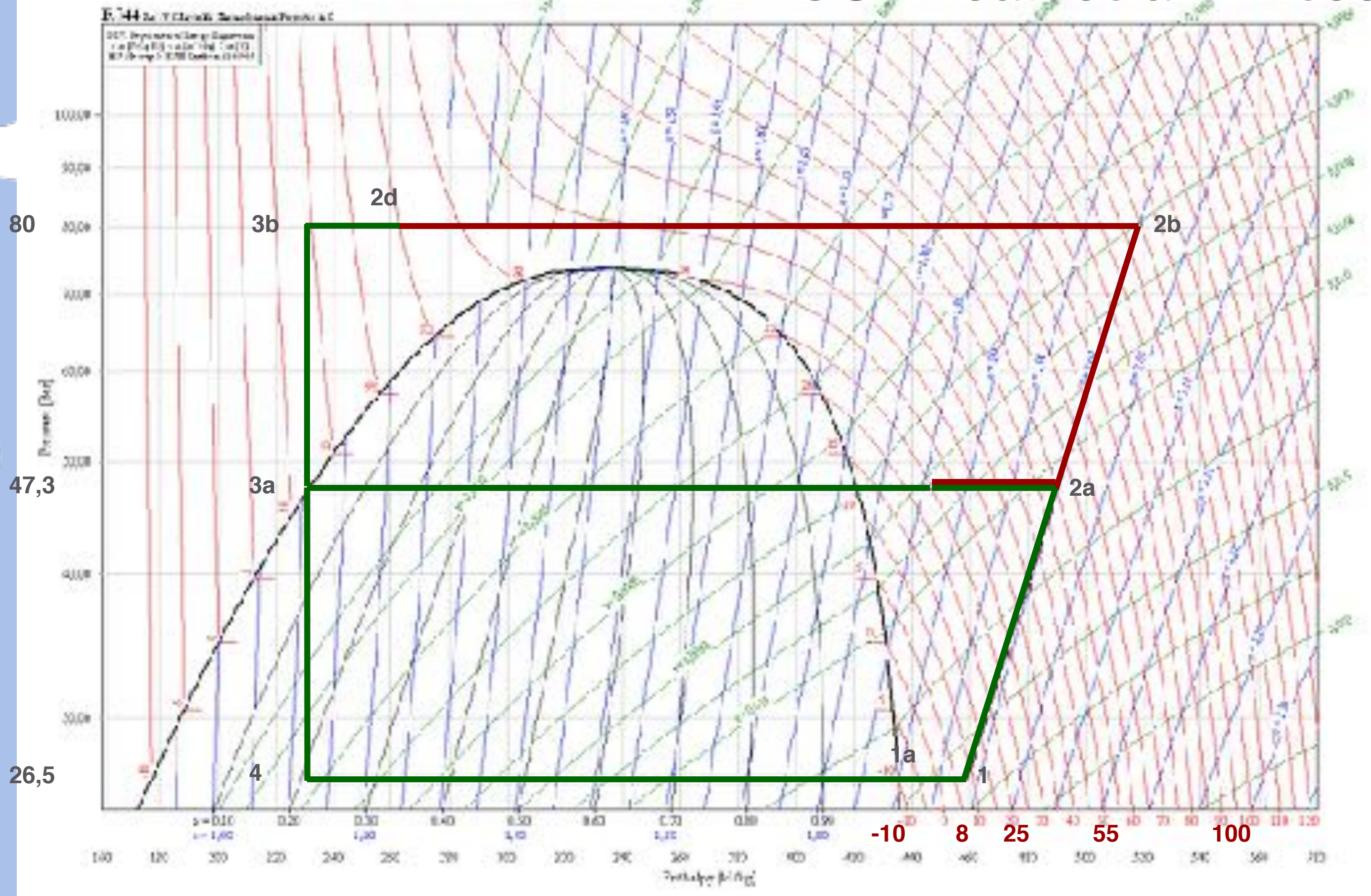
$$COSP = \frac{Q_{LT}+Q_{MT}+Q_{TW}+Q_{SH}}{W_{LT}+W_{MT}} \quad (5)$$

Surce
15[th] EUROPEAN CONFERENCE, TECHNOLOGICAL INNOVATIONS IN REFRIGERATION AND IN AIR CONDITIONING
POLITECNICO OF MILAN 7[th]-8[th] June 2013

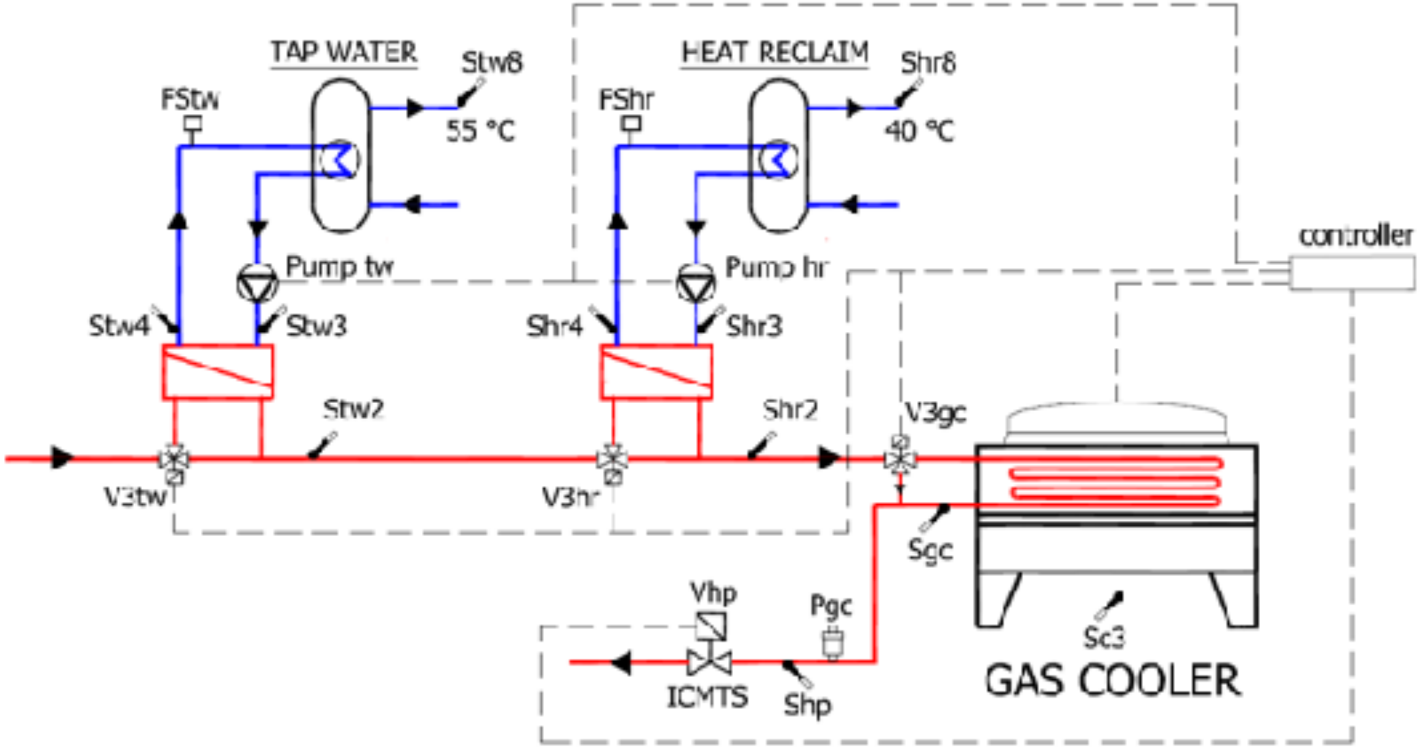
Heat reclaim with CO_2

COP Cooling ≈ 6.7

COP heat reclaim + cooling ≈ 8



Heat reclaim with CO_2



- Control of hot Tap Water temperature With 3-way by-pass valve
- Control of additional Heat reclaim source e.g. floor heating with 3-way bypass valve
- Additional input (0-10V) to activate HR steps
- VSD (AKD, 0-10V) control of fans and water pumps to control water temperature
- Independent control of each subsystem, including safety conditions

Heat reclaim with CO_2

Heat Reclaim realized in 4 stages:

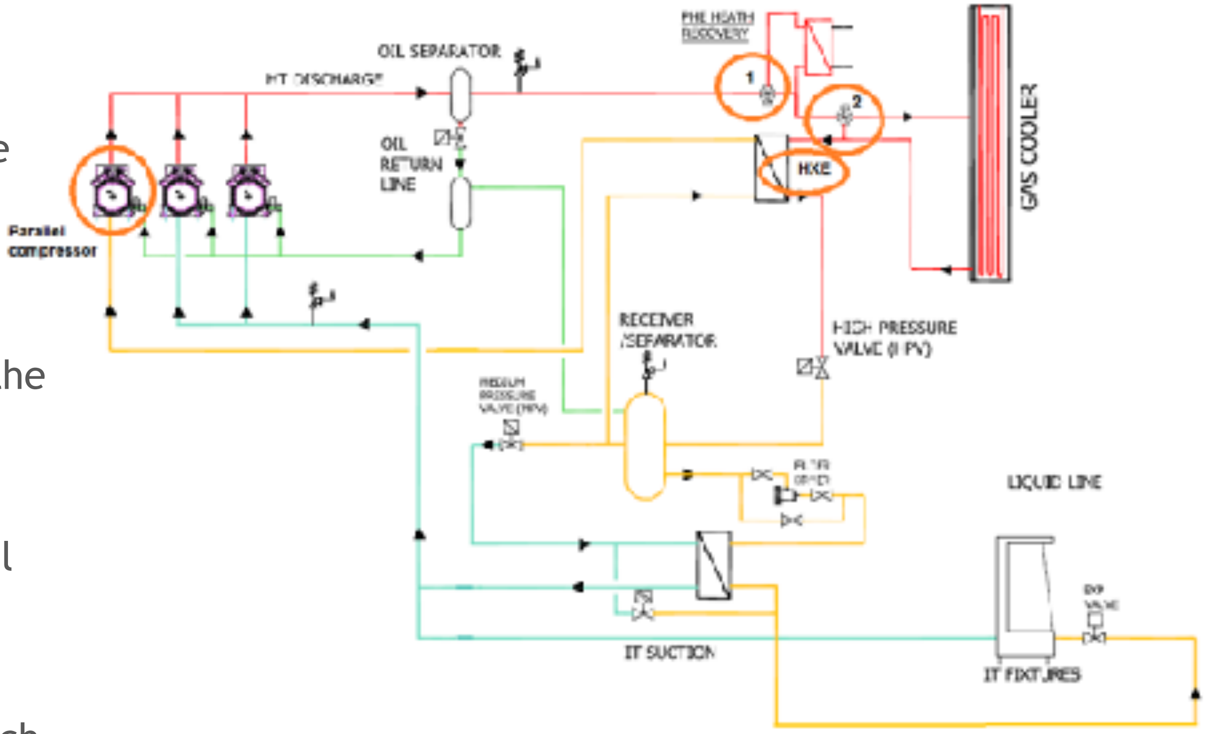
Stage 1: Activate HR. Valve 1 open.

Stage 2: Raise the system pressure. With the increasing of the heating demand the head pressure is increased consequently

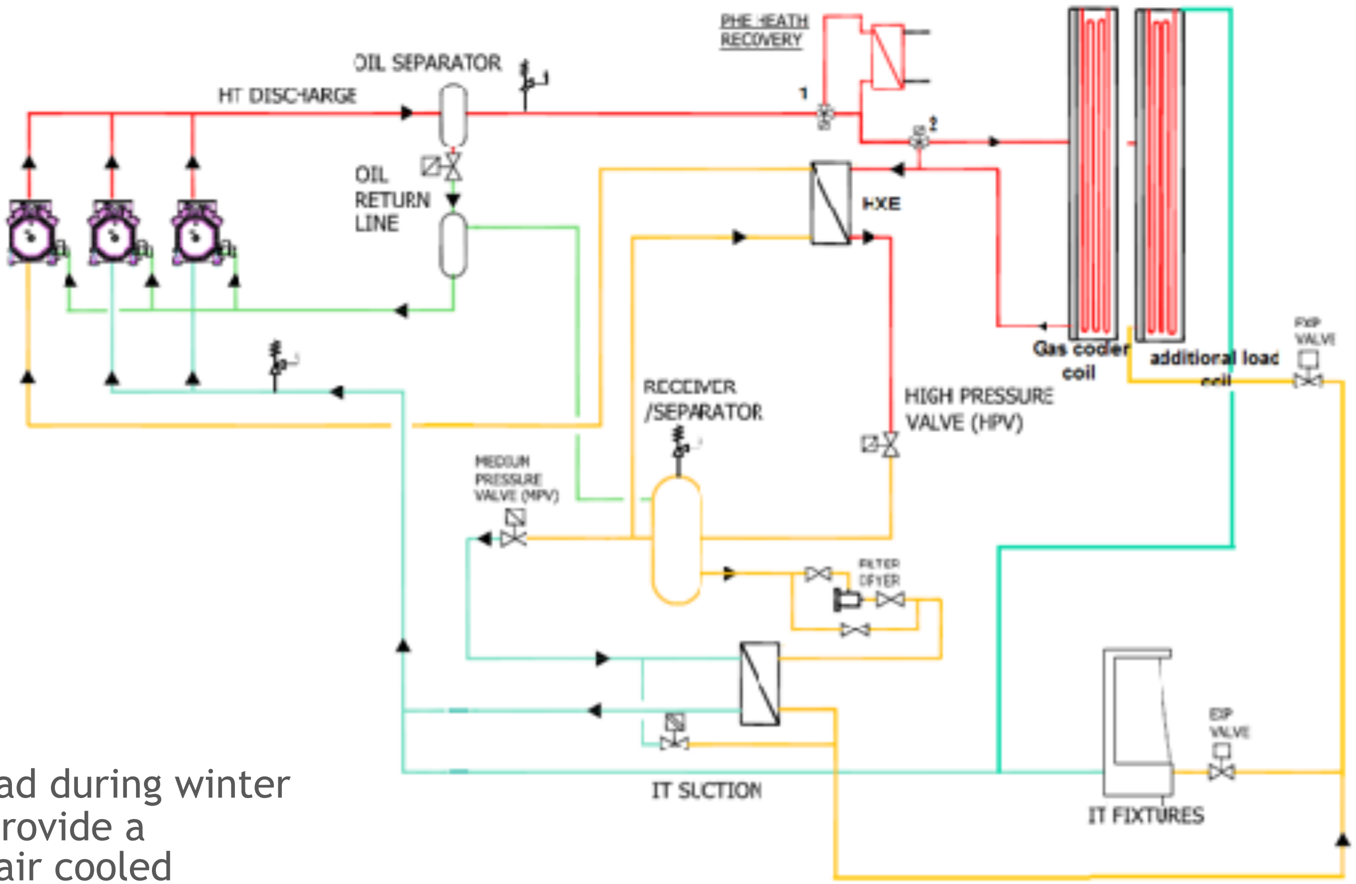
Stage 3: Stop gas cooler fans.
To allow the increasing of the heating load the gas cooler fans are stopped.

Stage 4: By-pass gas cooler.
In this way the HR exchanger become a total heat recovery and heating load is maximum

When Stage 2 is activated the flash gas concentration will raise in the Receiver, which will activate parallel compressors.

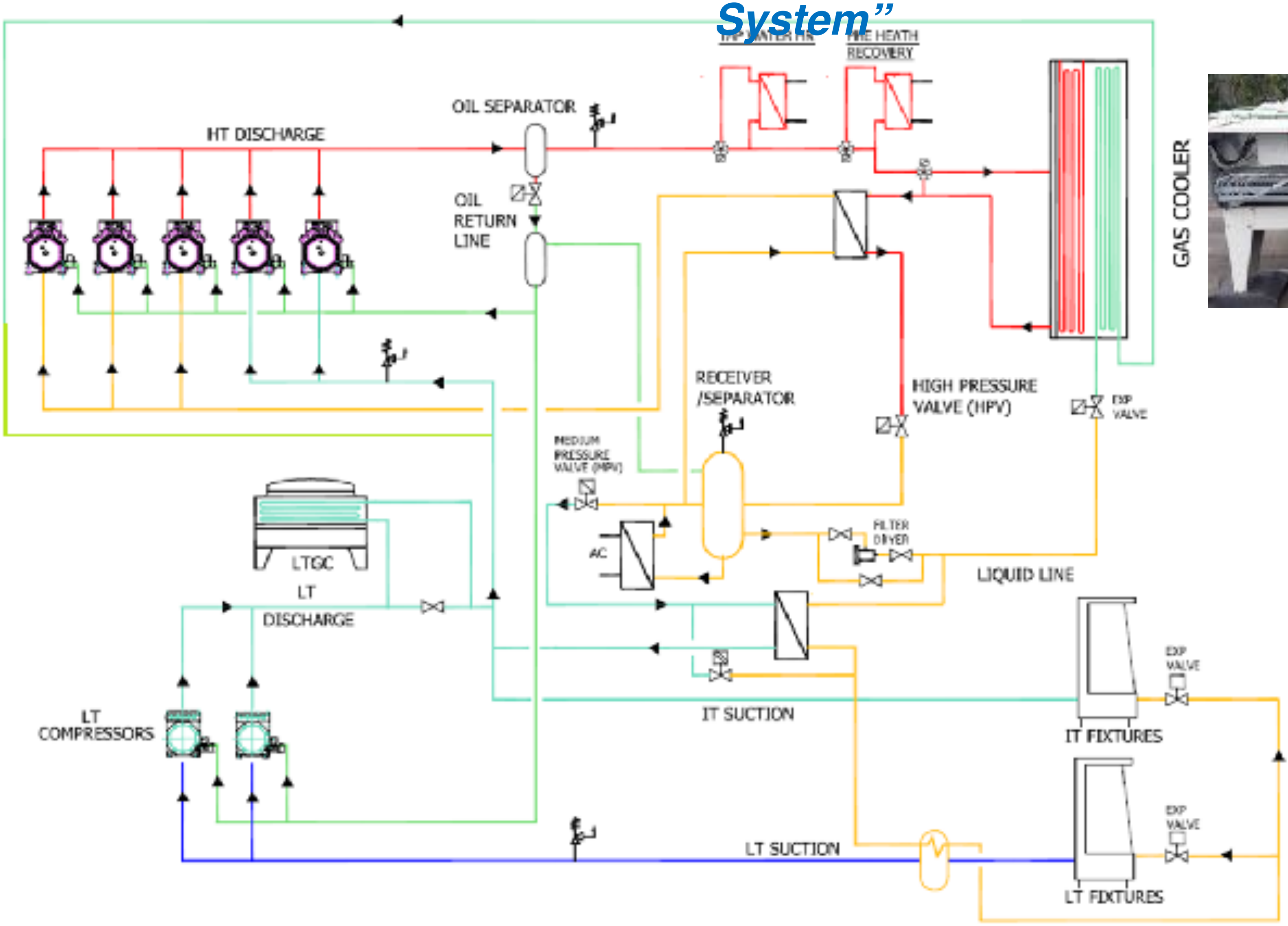


Heat reclaim with CO_2



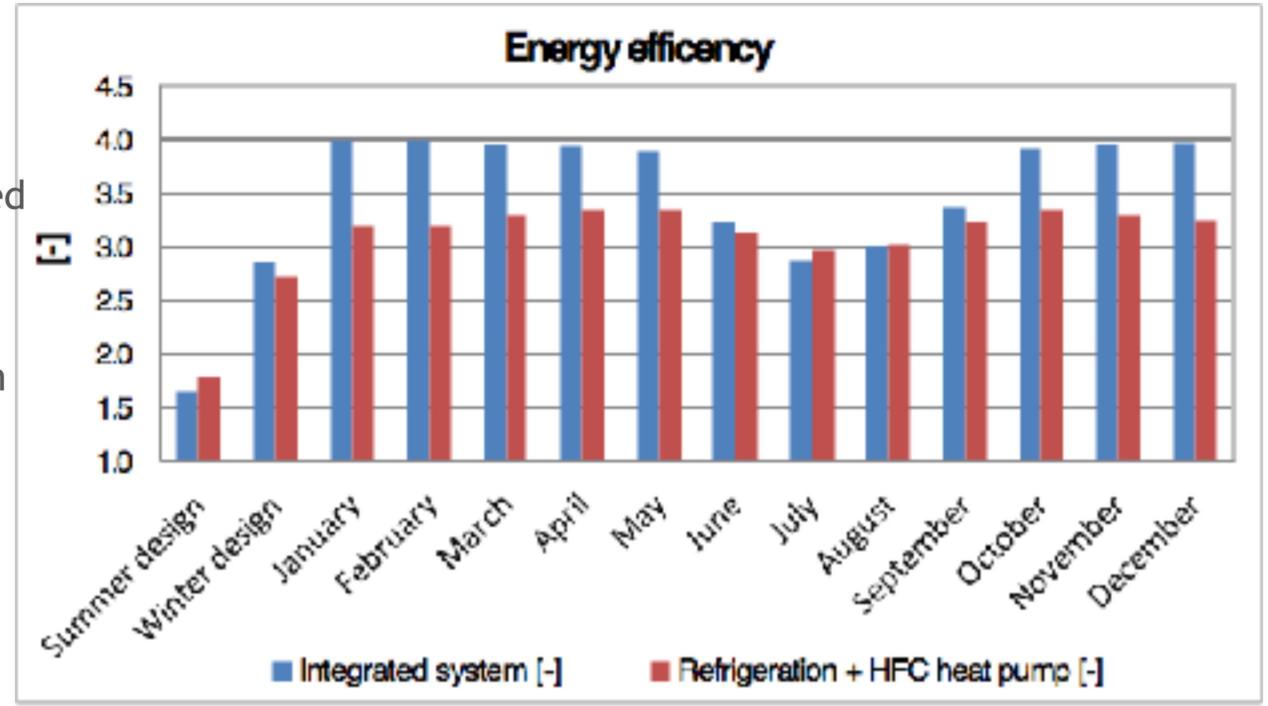
For stores where cooling load during winter and night could be low to provide a sufficient heating load, an air cooled evaporator, integrated in the gas cooler coil, is connected at the unit suction side as additional load.

Heat reclaim with CO_2 : The “Full integrated System”



Heat reclaim with CO_2 : The "Full integrated System"

The integrated systems appears a convenient solution from the energy and cost point of view.
The system is particular suited to reduce winter space heating associated cost by using total heat recovery from the refrigeration plant high pressure side.
In summertime, the integrated system energy efficiency equals that of the traditional system.
Considering winter strongly reduced energy cost, the lower capital and maintenance costs together with the reduced encumbrance and noise (no heat pump needed), the integrated system definitively over performs traditional solutions.



Trans Gourmet Poland
- Total Load HT 540 kW @ -7/36°C gcout
- Total Load LT 188 kW @ -31°C
- HR 270 kW @ 50/70°C water
- Parallel Compression, Hot Gas Defrost for LT coolers,
- 2 units (indoor version)

Logistic Sweden
- Total Load HT 600 kW @ -10/34°C gcout
- Total Load LT 220 kW @-33°C
- HR 500 kW @45/60°C water
- 4 units Booster, PNC version

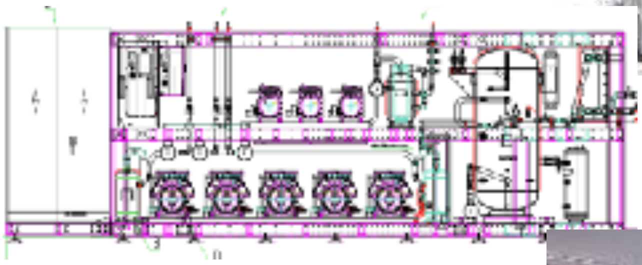
SCA NORMANDIE big LT logistic platform for LECLERC
- **Total Load LT 350 kW @-32°C**
- 6+6 compressors execution
- Great <u>plant reference</u> in France for CO_2 industrial applications

Rabbit Belgio
- Load HT DX 440 kW @ -5/35°C gcout
- Chiller LOAD 115 kW @ propylen glycol +3/0°C
- Load LT DX 11 kW @-30°C
- Walk in unit
- HR 250 kW @10/80°C water
- 1 unit (walk in version)

Mall of Scandinavia (Stockholm)
- Load HT DX 200 kW @ -10/35°C gcout
- Load LT DX 50 kW @-35°C
- HR 250 kW @30/60°C water

SCM FRIGO MWT 6x178 MTDX + UMCE 4x040 BT/S
Booster equipped with Carel pR300t-regulator
2 p.c LUVE XAV9 9913 V 3VENT gascooler.
All is controlled by Carel – regulators , One PlantVisor regulates valves and have total control of the system .

Logistic Platform LIDL Pontedera (Italy)
SCM FRIGO 2 x MWT 4x260 MTDX +UMCE 4x090 BT
Total Load HT 200 kW @ -8/36°C gcout
Total Load LT 200 kW @ -36°C
HR 150 kW @45/55°C water

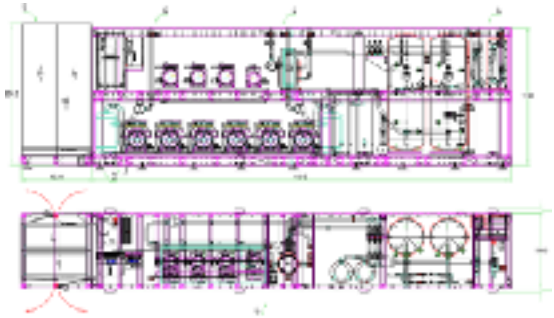


Centre Leclerc (ARRAS – France)
- Load HT DX 290 kW @ -10/36°C gcout
- Load LT DX 40 kW @-35°C
- HR 250 kW @45/55°C water

SCM FRIGO MWT 5x300 MTDX + UMCE 3x045 BT
Booster MT-LT

ICE Rink Mechelen Belgium
SCM FRIGO MWT 4x380 MTDX
pump system CO_2, vessel 7200lt 45bar with total heat recovery and Air Handling Unit additional load

- Load HT 460 kW @ -10/25°C gcout
- Load HT (summer) 300 kW @ -10/36°C gcout
- HR 210 kW @30/45°C, 60 kW @55/65°Cwater

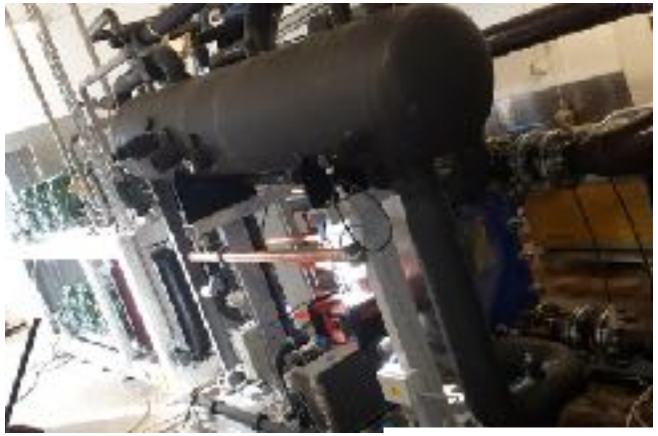


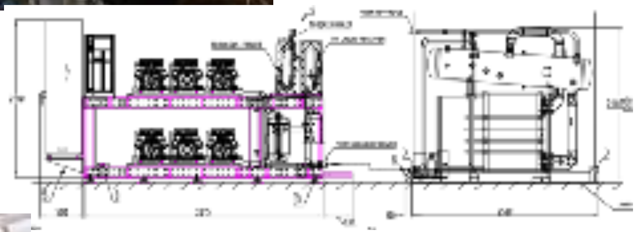
Centre Leclerc IFS (SAINT DESIR – France)

- Load HT DX 360 kW @ -9/34°C gcout
- Load LT DX 72 kW @-34°C
- HR 275 kW @45/55°C water

SCM FRIGO MWT 2x300+4x380 MTDX + UMCE 4x060 BT
Booster MT-LT

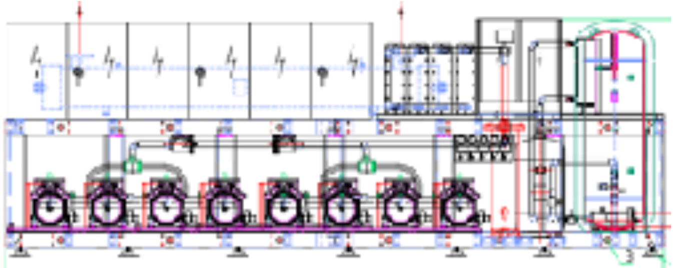
Industrial running projects





Ice Rink Sportcentrum Vänersborgs (Sverige)
SCM FRIGO MWT 4x380 MTDX
pump system CO_2, vessel 7200lt 45bar with total heat recovery and Air Handling Unit additional load

- Load HT 460 kW @ -10/25°C gcout
- Load HT (summer) 300 kW @ -10/36°C gcout
- HR 200 kW @+40/55°C water



Project NORLAKS (NORWAY) 2011

- Load HT DX 400 kW @ -6/32°C gco
- HR 250 kW @+40/55°C water

SCM FRIGO MWT 8x178 MTDX

Industrial Opportunities

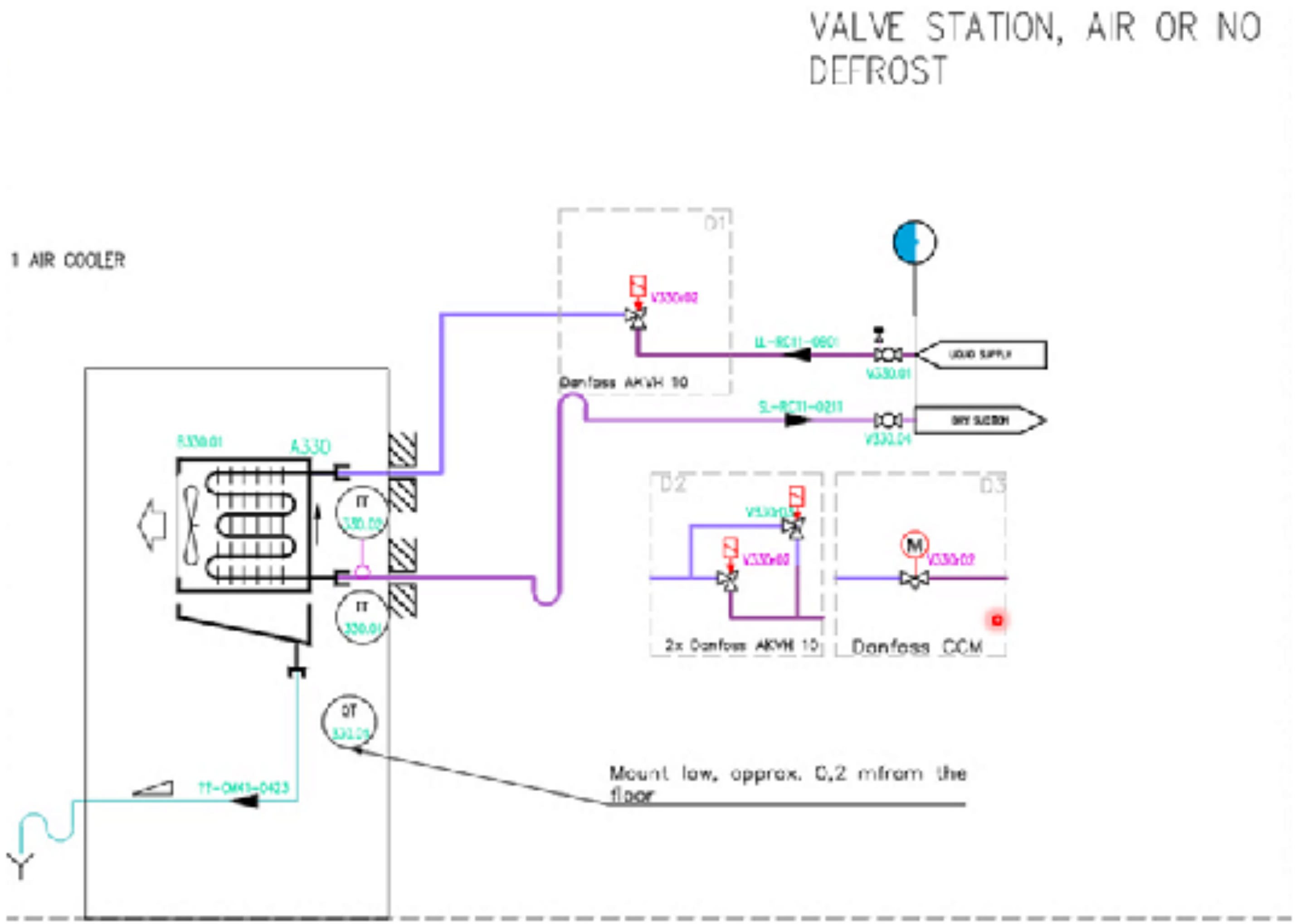
Italy

- We deliver by far the largest CO_2 Industrial Refrigeration job in the South of Europe, warmer climate.
- Logistic Platform for a company European LEADER in the Retailer Business
- 500 kW in Low Temp and 1.900 kW in Medium Temp, for a total of 2,4 MW of refrigeration, HR 1.250 kW MPG 55% +21°C/+27°C
- 48 Bitzer CO_2 compressors!

UK

- We deliver by far the largest CO_2 Industrial Refrigeration job in UK
- Logistic Distribution Platform for a company European LEADER in the Retailer Business
- 950 kW in Low Temp and 1.090 kW in Medium Temp, for a total of 2,05 MW of refrigeration, HR 500 kW water +45°C/+55°C
- 39 Bitzer CO_2 compressors!

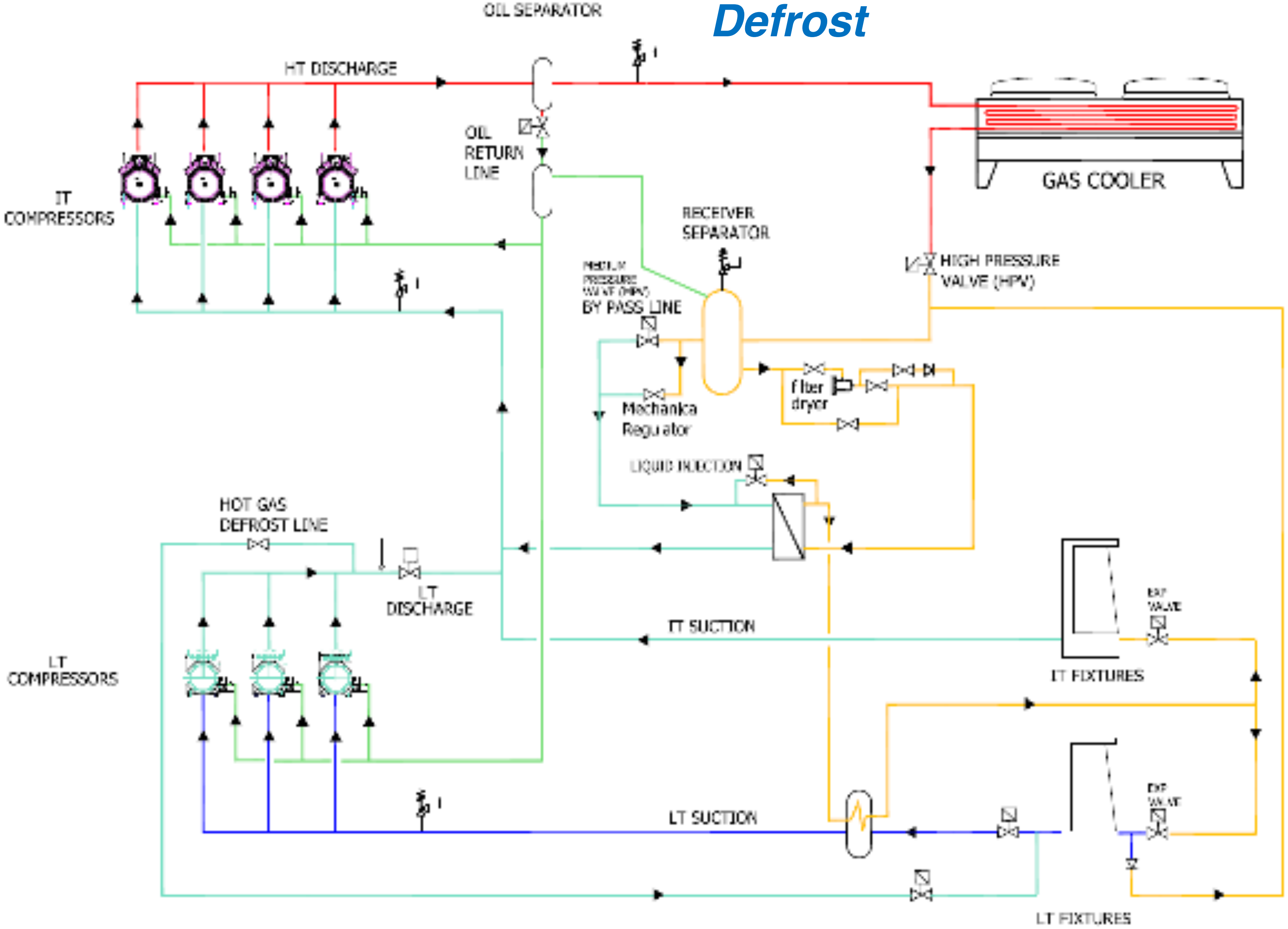
Defrost in a CO_2 refrigerating system: Air defrost



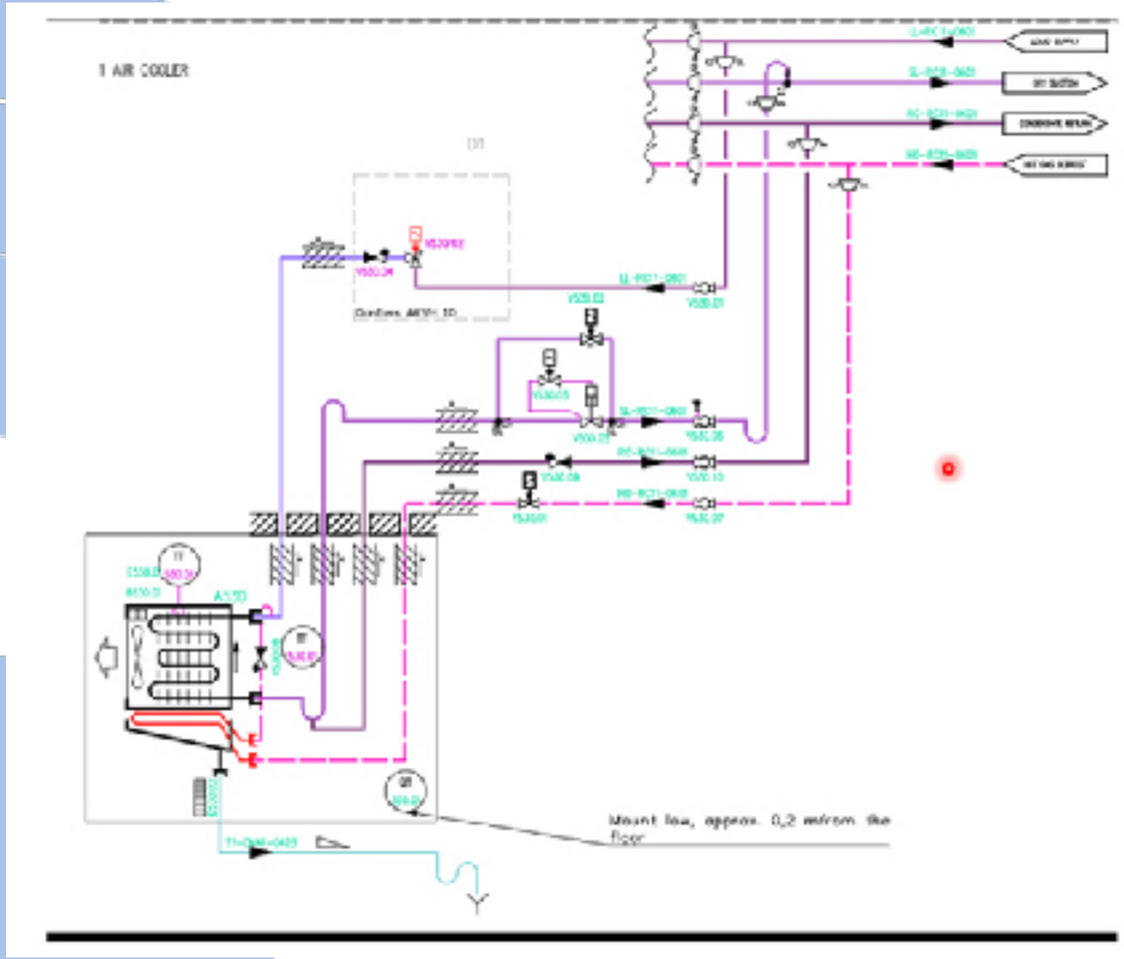
Filter before expansion valve not required (available)

Filter-dryer on compressor rack

Defrost in a CO_2 refrigerating system: Hot Gas Defrost



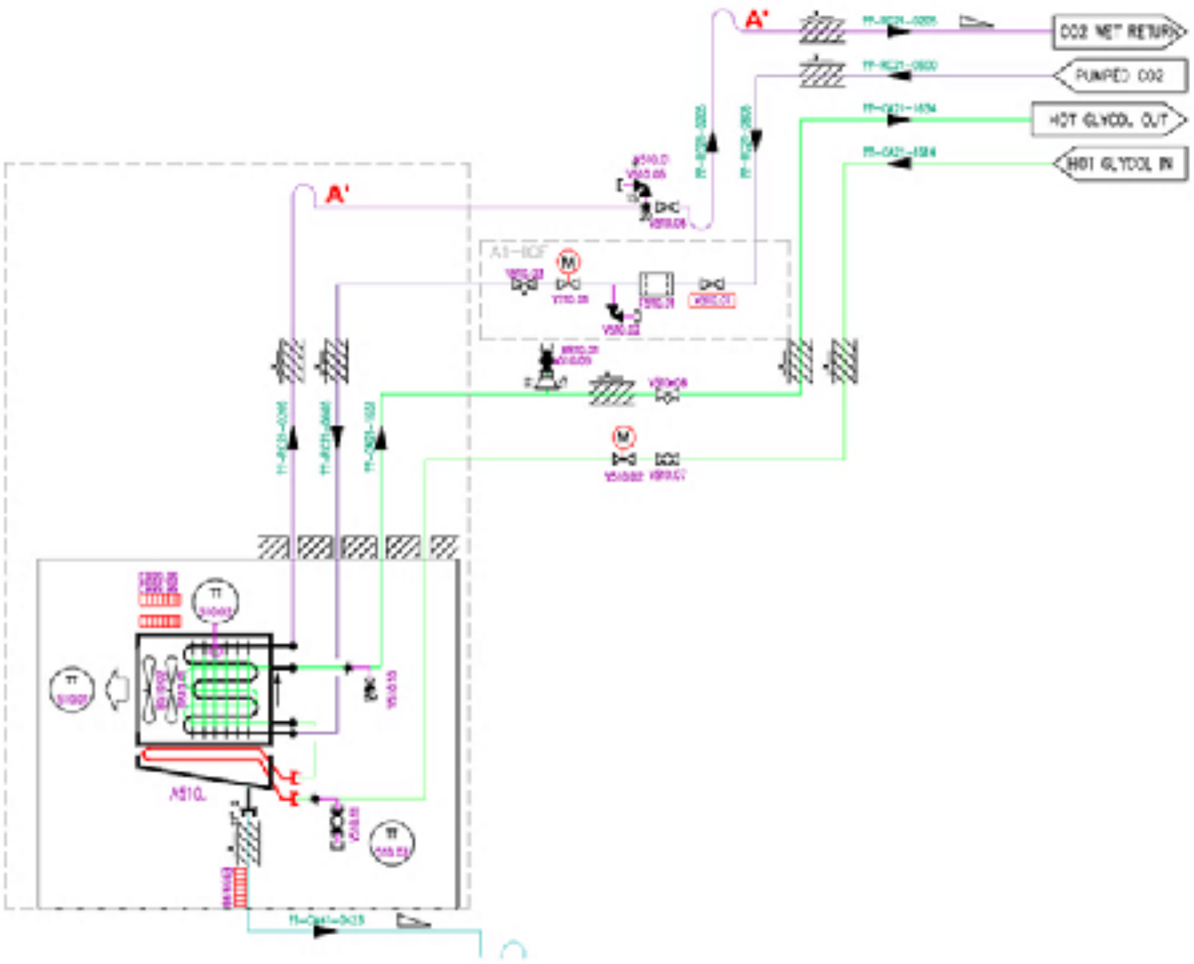
Defrost in CO2 Systems: Hot Gas Defrost



Additional components:

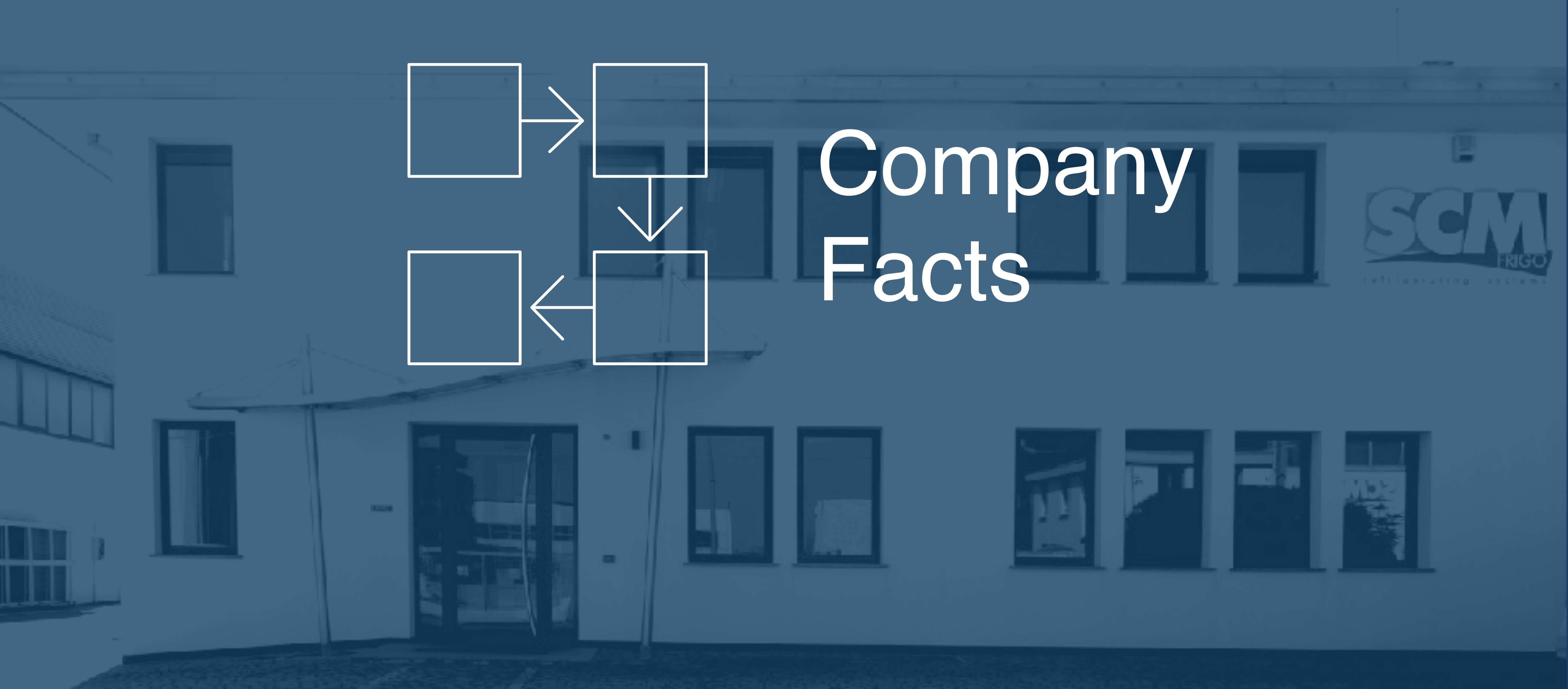
- Hot gas supply and condensate return lines
- Hot gas supply solenoid valve
- 3 x non return valve
- Big + small solenoid valve in suction line

Defrost in a CO_2 refrigerating system: Hot Glycol Defrost



Heat exchanger on CO_2 rack

Buffertank + pumps



Company Facts

Chronology

1979

SCM FRIGO establishment.
Production of units for Commercial and Industrial Refrigeration.

2004

Turnover SCM Group: **11 Mil €**
70% Italy; 30% Export.

2005

CO_2 - Subcritical rack systems.

2006

CO_2 - Transcritical Packs.

Chronology

2009

Listed supplier by **Sainsburys** for the huge CO_2 installations program.

July 2014

Beijer acquires 100% of SCM FRIGO S.p.A.

2015

Listed supplier by **Carrefour** for the huge CO_2 installations program.

2016

Listed supplier by **WMS Morrison's** for the huge CO_2 installations program.

Chronology

2017

Turnover SCM: **31 M€**
13% Italy; 87% Export

2018

BEIJER REF
ACADEMY

2018

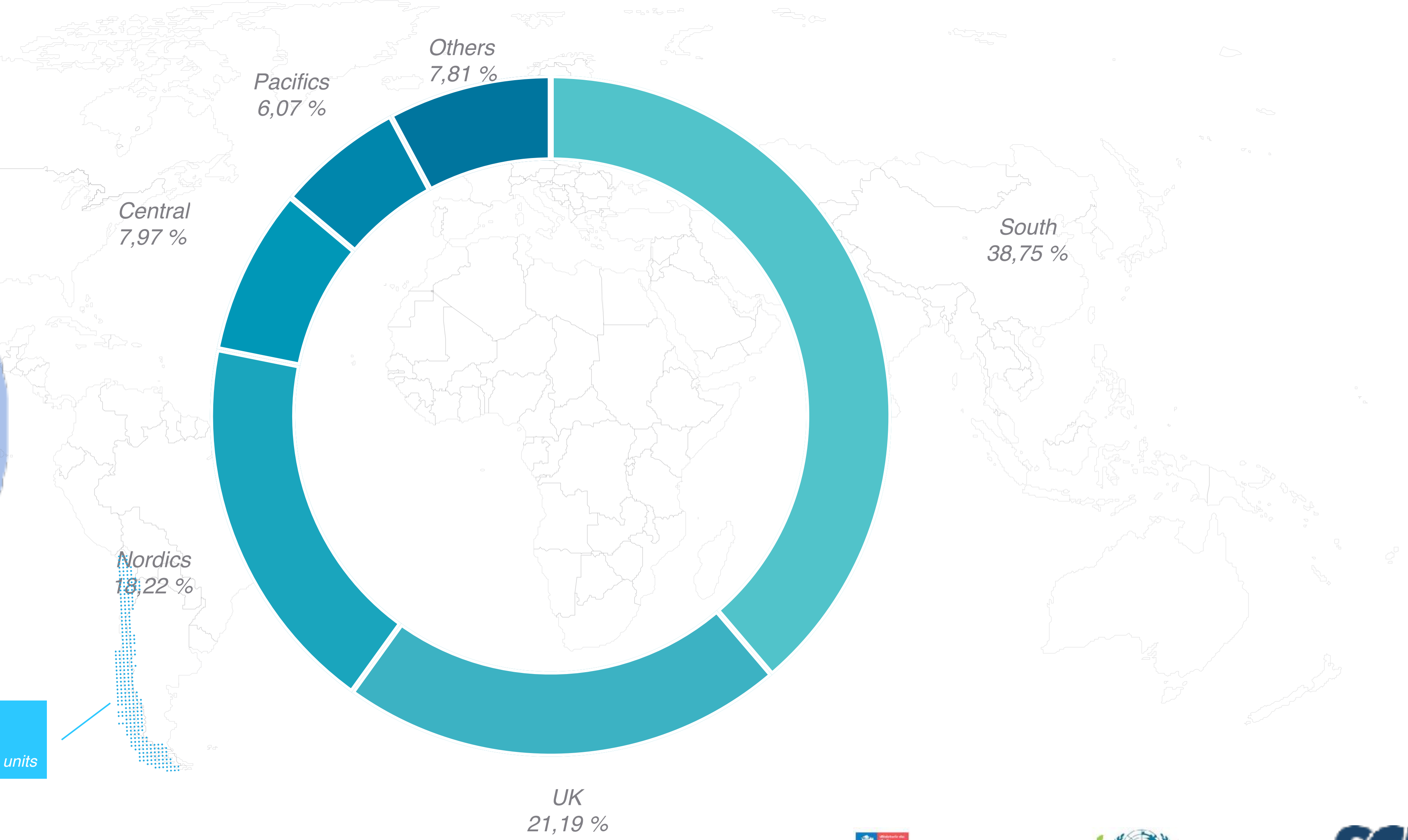
Turnover SCM Budget: ***35 M€***
12% Italy; 88% Export

High **Production** ***Potential***

We make unit design and assembling

Facility area, lead time, quality and price are optimized thanks to the procurement of semi-manufactured products made on our specifications from specialized sub-suppliers present in this area where approx 70% of the cooling units for the European market is built.

2017 Sales Distribution



Chile:
***5** CO_2 Running Installations*
*Coming Soon: **3** new transcritical units*

Products

CO_2 Range - **$Cubo_2$ SMART**

STANDARD CONFIGURATION

◊ DC Brushless Rotary compressor
◊ Inverter modulation 25% - 100%
◊ EC fans
◊ Small footprint
◊ K 65 connections
◊ Design pressure:
120 bar (high pressure side)
80 bar (liquid line)
80 bar (suction)

CO_2 Systems for medium and low temperature applications.

Transcritical condensing units DX

Model UMT T MTDX.
Cooling Capacity from 0,6 up to 8,5 kW.
Model UMT T BTDX.
Cooling Capacity from 0,65 up to 6,6 kW.

CO_2 Range - **$Cubo_2$ PLUS**

STANDARD CONFIGURATION

◊ Semi Hermetic reciprocating compressor
◊ Frequency controlled compressor (MT line)
◊ EC fans
◊ K 65 connections
◊ Design pressure:
120 bar (high pressure side)
60 bar (liquid line)
60 bar (suction)

CO_2 Systems for medium and low temperature applications.

Transcritical condensing units DX

Model UMT MTDX.
*Cooling Capacity from 4,6 up to 34 kW.**
Model UMT BTDX.
*Cooling Capacity from 1,1 up to 12,5 kW. ***

**data referred to -10°C, 32°C ambient*

***data referred to -30°C, 32°C ambient*

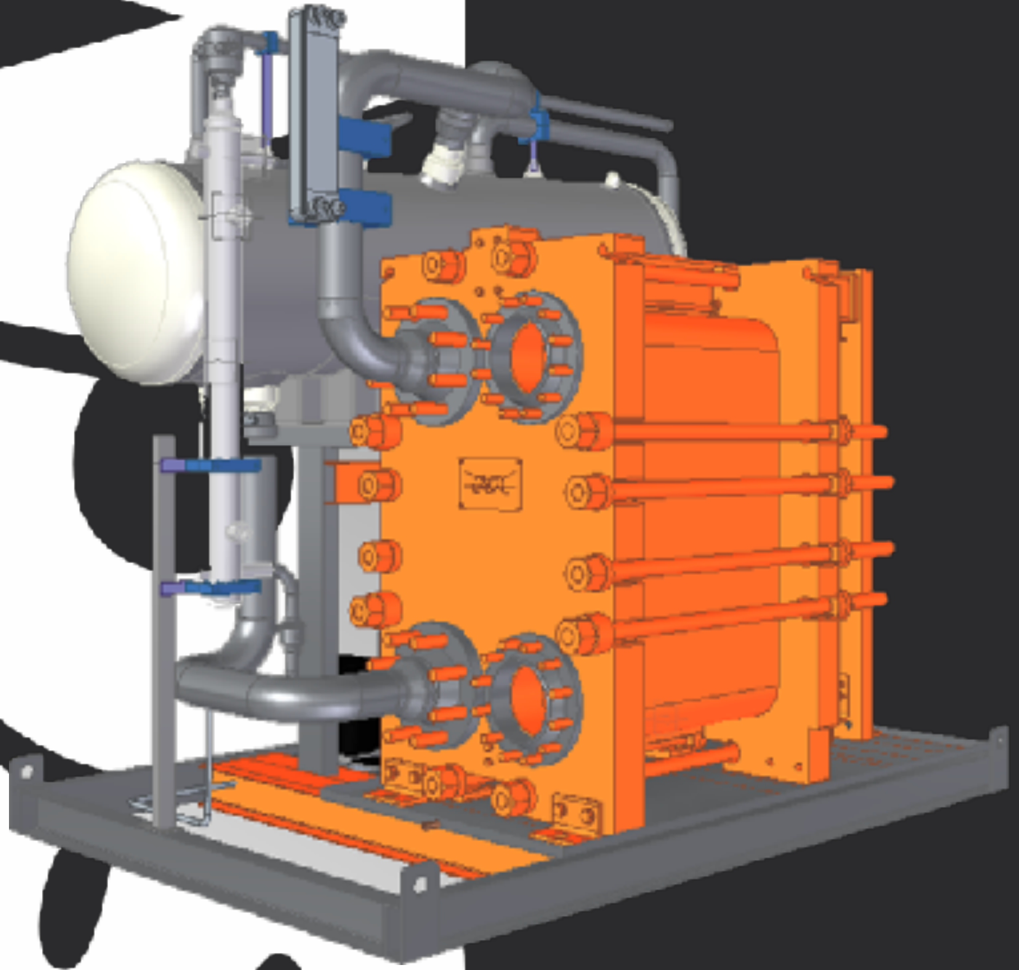
CO_2 Range – **Supermarket Booster**

CO_2 Transcritical Boosters for
SMKT and Industrial applications

Capacity 20-500 kW
Available for indoor, "walk in" box and "Plug'n cool"

A BEIJER REF Company
SCM FRIGO

CO_2 Range – **Chiller Modules**



CO_2 transcritical chiller **with flooded evaporator for MT application**

Cooling Capacity from 200 up to 700 kW.

A BEIJER REF Company

SCM FRIGO

CO_2 Range – **Smart Booster**

New range of Booster for VERY SMALL applications & convenience stores.

Capacity MT from 6 to 44 kW (max 2 cp, 1 FI driven)

Capacity LT from 2 to 12 kW (max 2 cp, option FI on the leading cp)

Compact execution (welded frame)

Oil management with oil sep with integrated reservoir

Compressors oil level regulator Traxoil

Liquid Receiver 70 liters PS 90 bar

Danfoss HP and MP valve CCMTS

1x HR level (3-way valve) OPTIONAL

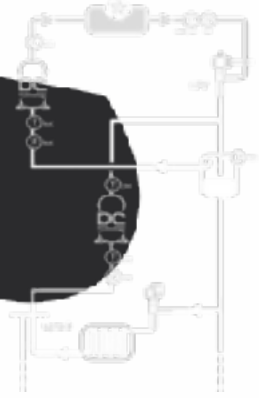
Electrical board with Danfoss AKPC 772

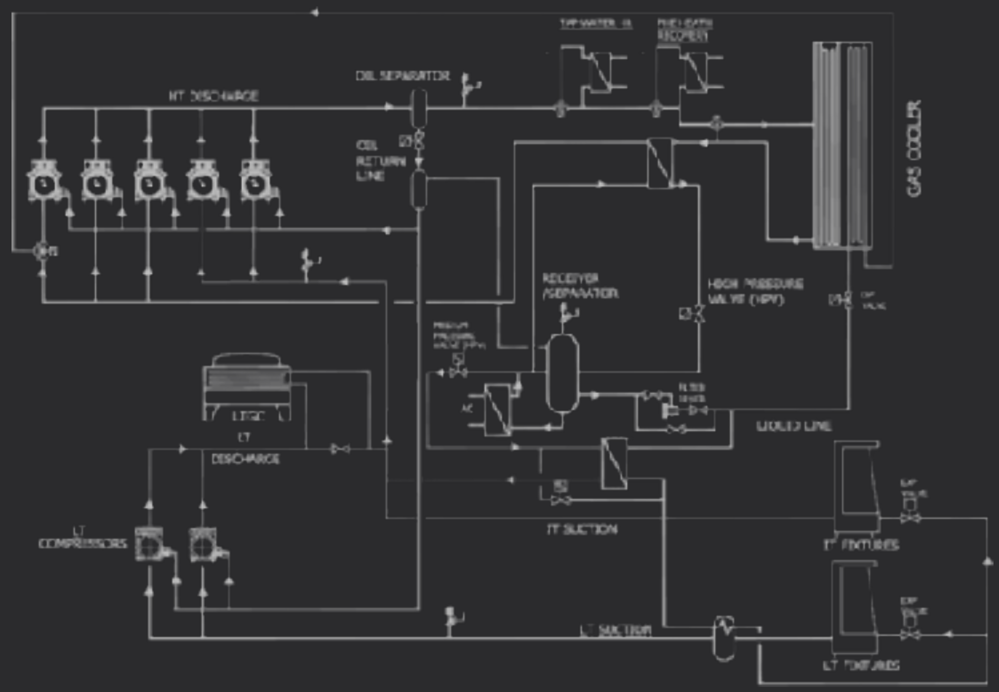
CRII (Bitzer IQ, 15%-100% modulation)
→ option when available (0-10V)

LSPM Line Start Permanent Magnet
→ option when available (0-10V)

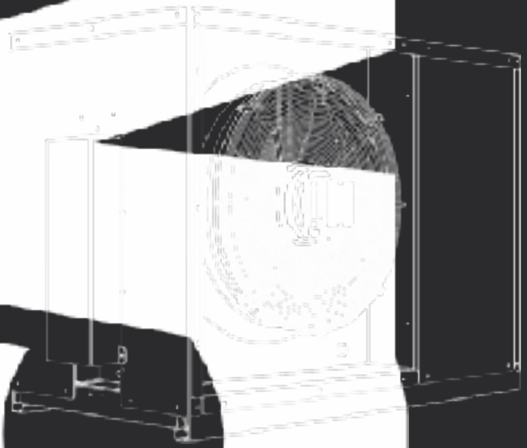
From Basic to the highest Skills

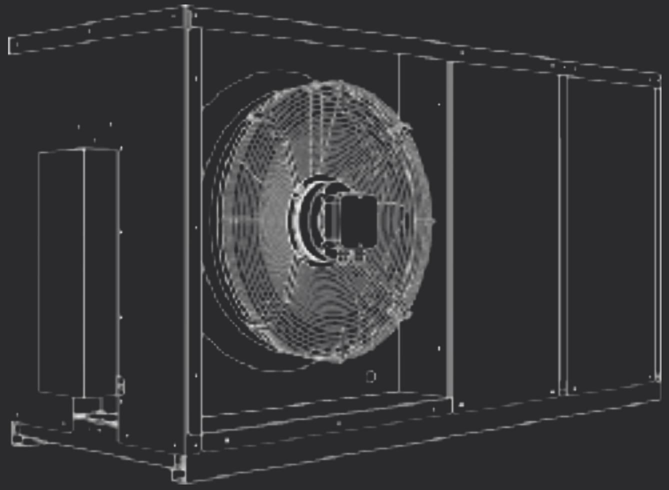
REFRIGERANT DIAGRAM RANGE

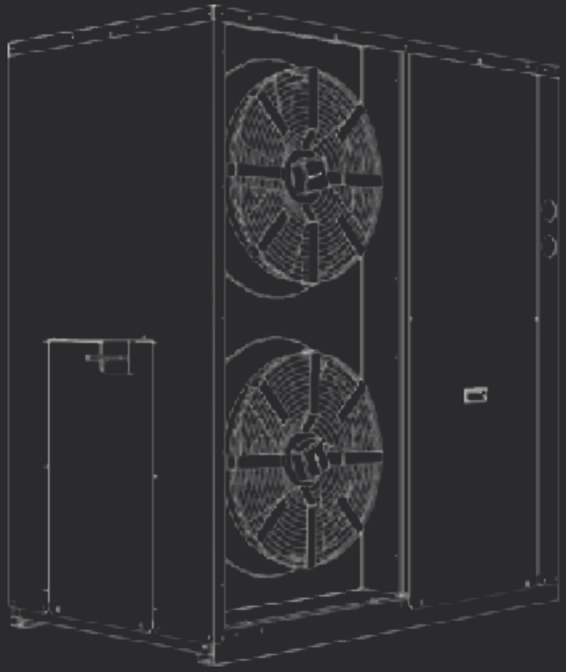




CO_2 Leadership





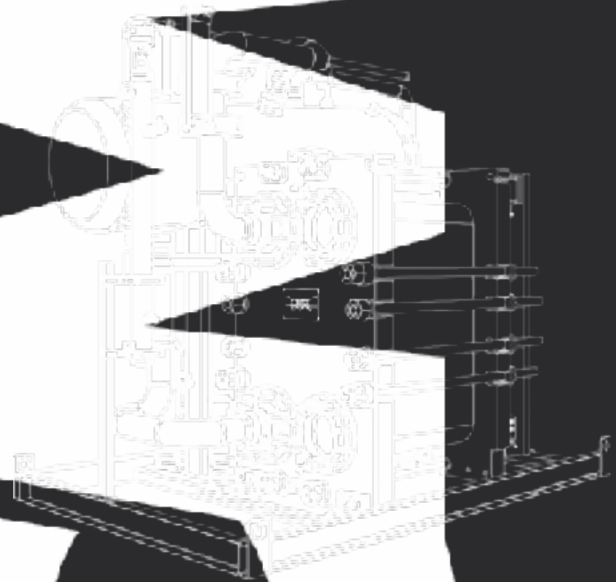


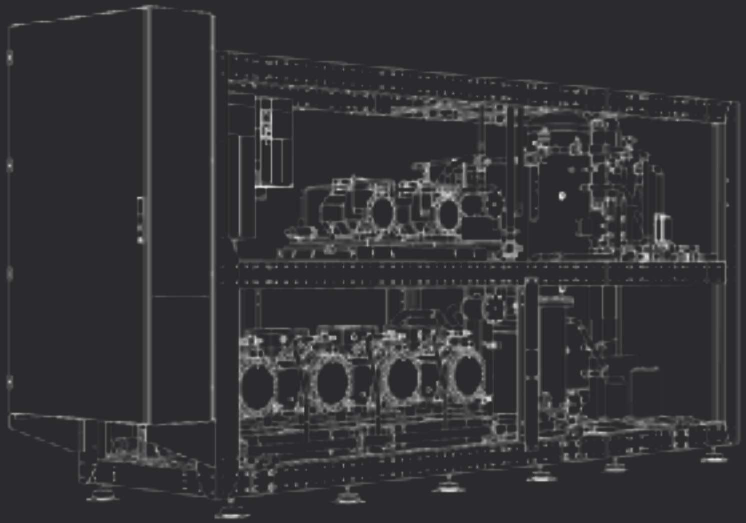
More than 2500 transcritical units in running installations

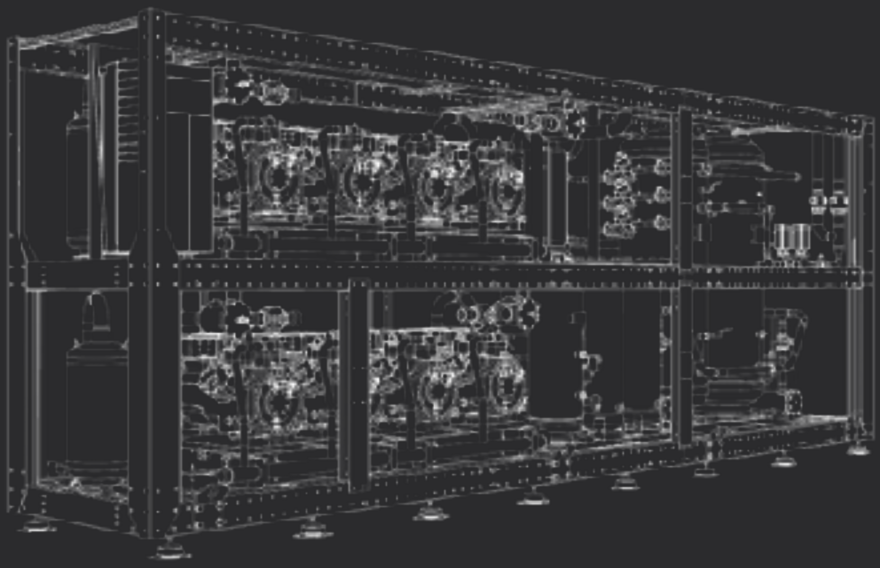
Flexible in the production, fast delivery times due to very good sub suppliers chain.

We produce ***a wide range of R744 applications*** (indoor booster, walk in, reach in, only HT, chillers, condensing units).

CO_2 Leadership







Huge knowledge of different compressors brand (Bitzer, Dorin,
Bock) and Controller type
Danfoss, RDM, Dixell. JTL) in
itical plants.

Cooperation with ***Padua University.***

Constant commitment in finding new solutions to ***improve efficiency and simplify our systems, using our Beijer Ref Academy***

HFC Range – **Cubo PACKS - Commercial**

MC

HFC DX

Medium and Low Temperature applications
Model MC:
condensing units with 1 compressor

Cooling Capacity from 1 kW up to 65 kW.

Std pistons or scroll compressor.

Available with R134a, R407F, R448A, R449A, R450A refrigerant.

R452A on request.

MC-LC / MCC-LC

HFC DX

Medium and Low Temperature applications

Model MC-LC: condensing units with 1 compressor, closed frame and without condenser

Model MCC-LC: compressor packs with 2 or 3 compressors in parallel, closed frame and without condenser

Cooling Capacity from 1 kW up to 90 kW.

Std pistons or scroll compressors.

Available with R134a, R407F, R448A, R449A, R450A refrigerant. On request R452A.

MCC

HFC DX

Medium and Low Temperature applications
Model MCC:

compressor packs with 2 or 3 compressors in parallel

Cooling Capacity from 5 kW up to 65 kW.

Std pistons or scroll compressors.

Available with R134a, R407F, R448A, R449A, R450A refrigerant.

R452A on request..

HFC Range – **Industrial**

INDOOR

OUTDOOR

HFC DX

Low Temperature applications

Model UMA: condensing units (indoor and outdoor).
Model UMCA: compressor packs (indoor and outdoor) Cooling Capacity from 50 kW up to 600 kW.
Std pistons, two-stage or screw compressors HSN type.
Available with R134a, R407F.
On request R448A, R449A, R450A, R452A.

HFC DX

Medium Temperature applications

Model UMA: condensing units
Model UMCA: compressor packs
Cooling Capacity from 50 kW up to 500 kW.
Std pistons or screw compressors HSK type.
Available with R134a, R407F.
On request R448, R449, R450, R452.

HFC indirect system

with 2 or 3 independent refrigerant circuits

2, 3 or 4 pistons
or 2 screw compressors
Cooling Capacity from 50 kW up to 600 kW.
Designed as Std with EG30%,-4/-8°C.
Possibility to design in di erent conditions.
Available with R134a, R407F.
On request R448A, R449A, R450A, R452A.

Thank You!