OFFICINE MARIO DORIN SINCE 1918

DORIN®
INNOVATION

Introduction video

Dorin in numbers

4 companies

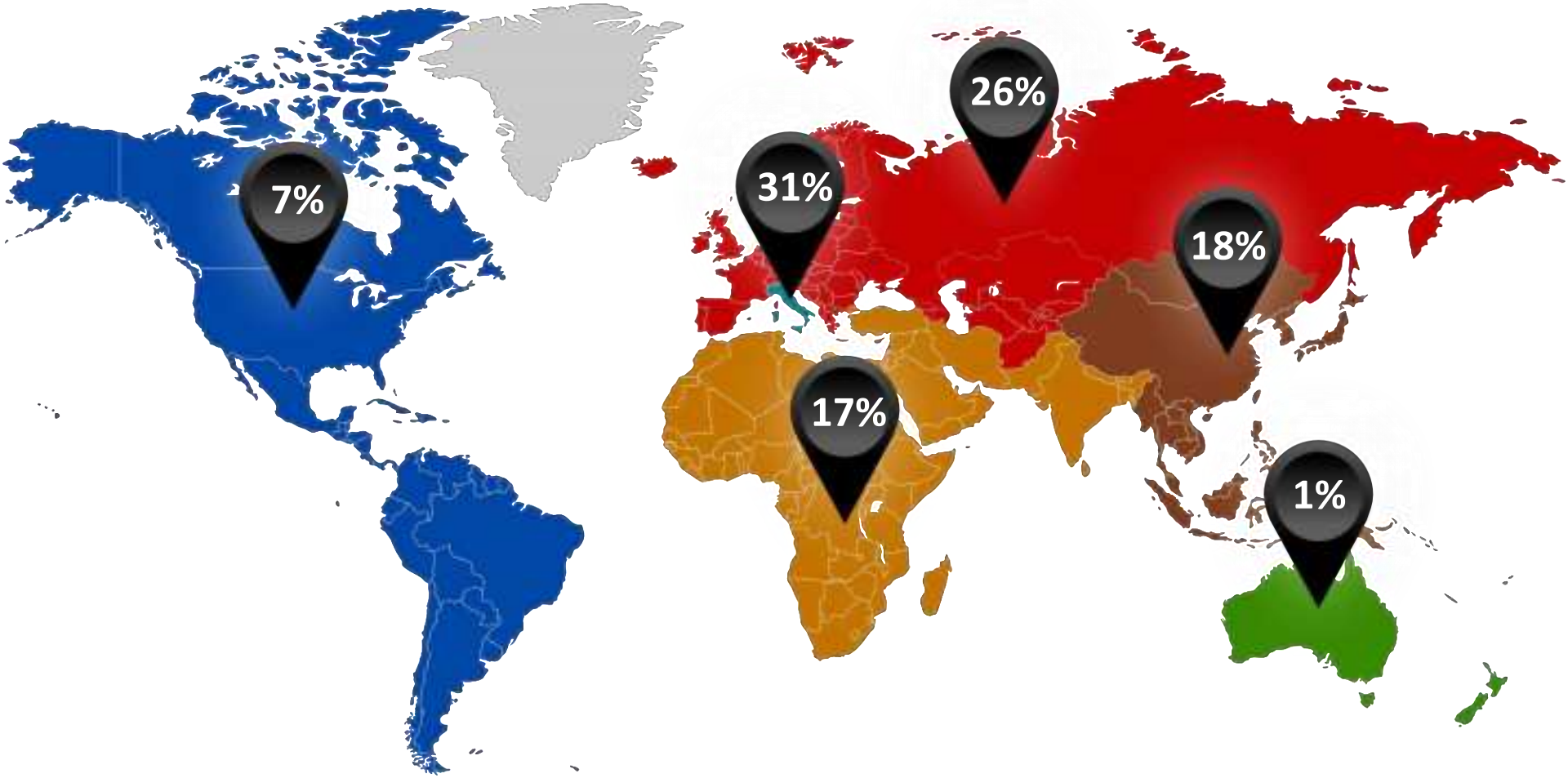
150 employees

To date: 65.000 manufactured compressors yearly

(over 300.000 pieces totally manufactured in Europe)

Go to market through local partnerships

Revenue distribution



A long way to excellence since 1918

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DORIN INNOVATION

First compressor in 1932

1930

1950
CFC

Leader in open type range

Special Range for R22
Inverter Technology
Prototypes in CO_2

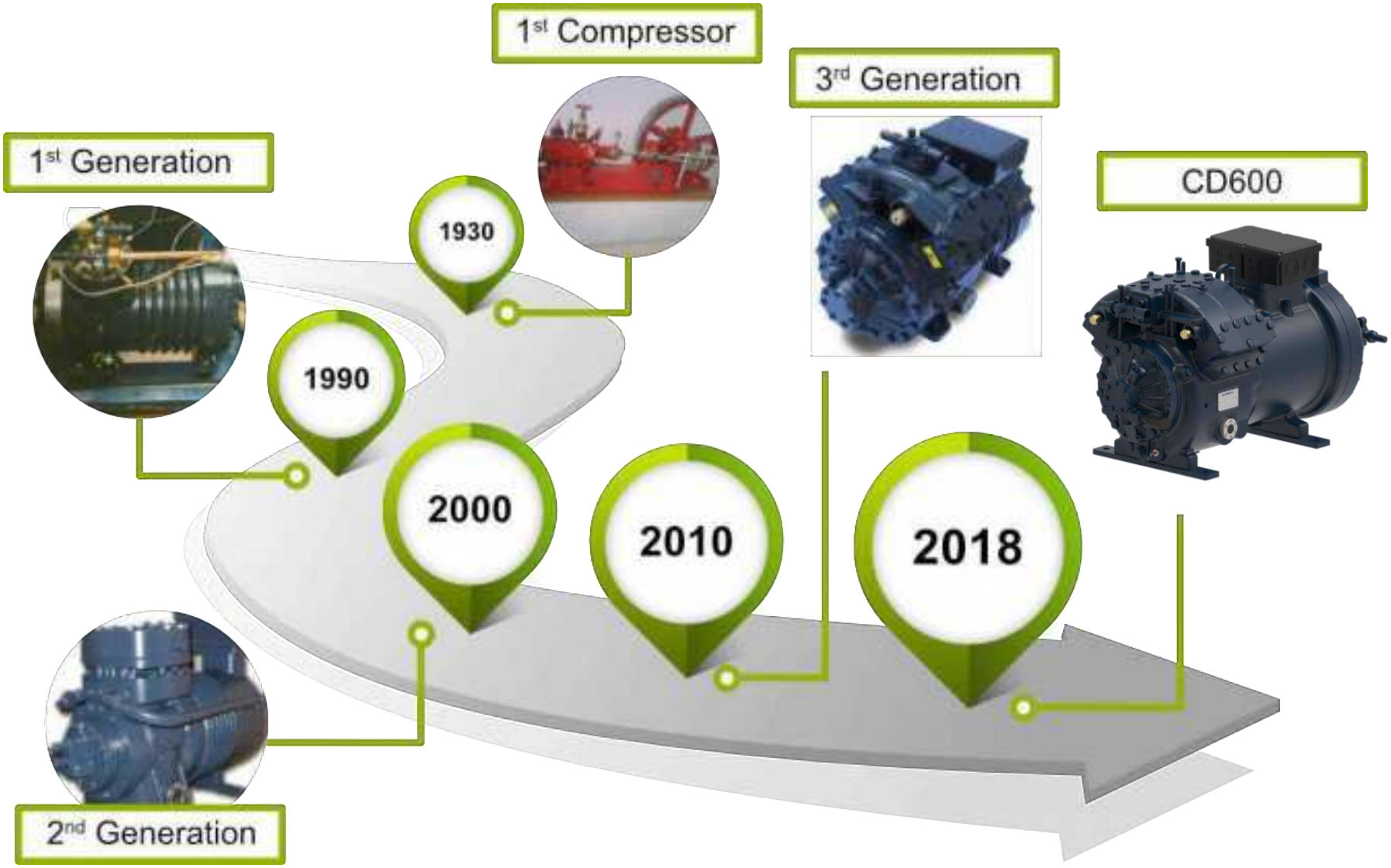
1990
HCFC

2010
HFC

NOW
???

Hydrocarbons
CO_2
Inverter
HFOs

CO_2 Compressor Evolution



CO_2 R&D

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1996

1° transcritical compressor built for SINTEF (Norway)

2010

1° prototype of 2 stage transcritical CO_2 compressor

2018

- New **CD600** range for transcritical application
- Up to **160 HP** and **81,95 m³/h** – 6 cylinders
- Largest refrigeration capacity range of compressor on the market

CO_2 2019 – NEW subcritical 8 cylinders compressors

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DORIN INNOVATION

OFFICINE RADIO DORIN SINCE 1918

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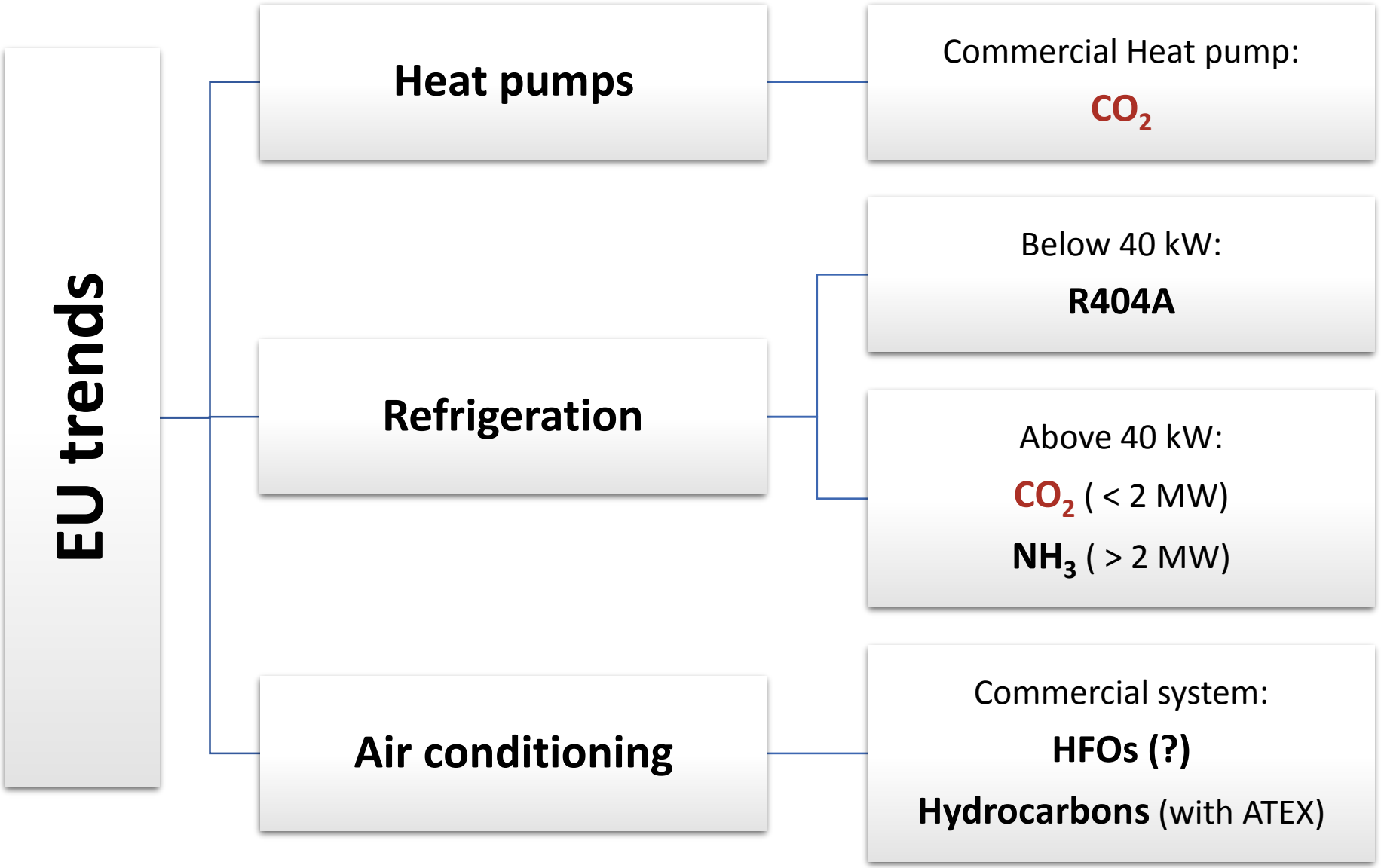
F-GAS REGULATION


EU trends
Heat pumps
Commercial Heat pump:
CO_2
Refrigeration
Below 40 kW:
R404A
Above 40 kW:
CO_2 (< 2 MW)
NH_3 (> 2 MW)
Air conditioning
Commercial system:
HFOs (?)
Hydrocarbons (with ATEX)

EU F-Gas regulation

Refrigerant	R404A	R410A	R407A	R407F	R407C
Natural refrigerant	no	no	no	no	no
ODP *(Ozone Depletion Potential)*	0	0	0	0	0
GWP *(Global Warming Potential)*	3922	2088	2107	1825	1774
Safety group	A1	A1	A1	A1	A1
Critical temperature [°C]	73	72,13	83	83	87
Temperature glide [K]	0.7	1	6.6	6.4	7.4
COP (-35/45°C)	1.20	-	1.20	1.22	OUT
COP (-5/45°C)	2.34	-	2.48	2.5	2.63
	2020				**2022**

Refrigerant	R449A	R134a	R32	R513A	R1234ze	R1234yf	R290	R1270	R717	CO_2
Natural refrigerant	no	no	no	no	no	no	yes	no	yes	yes
ODP *(Ozone Depletion Potential)*	0	0	0	0	0	0	0	0	0	0
GWP *(Global Warming Potential)*	1397	1430	675	573	7	4	3	3	0	1
Safety group	A1	A1	A2	A1	A2L	A2L	A3	A3	B2	A1
Critical temperature [°C]	82	101	78	96	109	94	96.7	92	132.3	31.1
Temperature glide [K]	5	0	0	0	0	0	0	0	0	0
COP (-35/45°C)	1.22	OUT	-	-	-	-	1.31	1.19	-	-
COP (-5/45°C)	2.49	2.76	-	-	-	-	2.88	2.87	-	-
		JUST FOR CASCADE SYSTEM								

CO_2 Stores


CO_2 stores in global perspective
8,732
EUROPE
CANADA
163
118
UNITED STATES
1,800+
JAPAN
CHINA 2
INDONESIA 13
5 AUSTRALIA
BRAZIL 2
ARGENTINA 3
SOUTH AFRICA 63
16 NEW ZEALAND
CO_2
KEY/LEGEND
N/A 1-2 3-99 100+ 1000+

Case 1:
COMMERCIAL REFRIGERATION
Refrigerant and Refrigeration systems comparison

Supermarket specs:
- condensation: 45°C
- evaporation: -10°C (MT), -35°C (LT)
- MT: 150 Kw
- LT: 50 Kw

Ing. Mauro Bonfanti

SYSTEM – MT: R134a – LT: R404A

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MT System

- R134a
- 4 compressors H2400EP

Evap: -10°C

Cond: 45°C

COP: 2.43
Power consumption: 62.12 KW

LT System

- R404a
- 3 compressors H4000CS

Evap: -35°C

Cond: 45°C

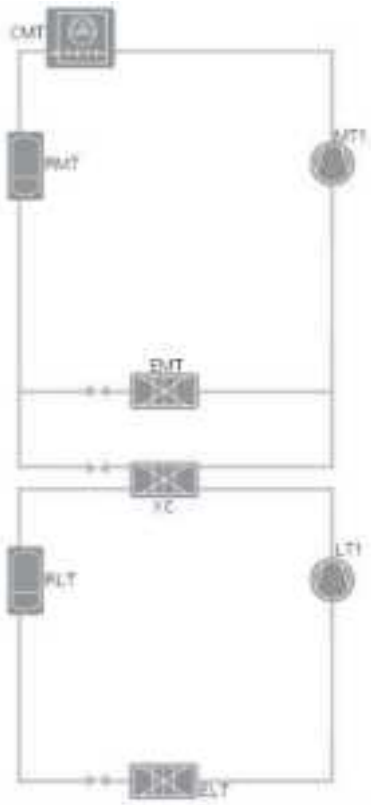
COP: 1.14
Power consumption: 46.44 KW

MT/LT SYSTEMS

COP: 1.84 kW
Power consumption: 108.56 KW

Ing. Mauro Bonfanti

CASCADE SYSTEM – R290/R744 (CO2)



CMT: Condenser MT (MT heat rejection air or water heat exchanger)
RMT: Receiver MT (MT refrigerant charge storage tank)
MT1: Compressor MT 1 (Compresses vapour from MT to high pressure side)
EMT: Evaporator MT (MT display cabinets and cold rooms)
XC: MT-LT evaporator-condenser (LT to MT heat rejection dedicated heat exchanger)
RLT: Receiver LT (LT refrigerant charge storage tank)
LT1: Compressor LT 1 (Compresses vapour from LT to MT pressure side)
ELT: Evaporator LT (LT display cabinets and cold rooms)

Cascade System

First stage:

- R290
- 4 compressors HEX4000CS

Second stage:

- R744 (C02)
- 2 compressors CD1500B

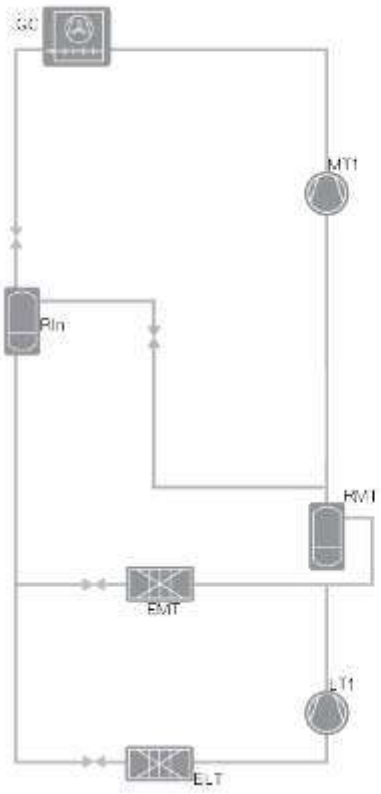
COP: 1.93

Power consumption: 103 KW

-5% energy

Ing. Mauro Bonfanti

BOOSTER Flash gas by-pass – CO2



GC: Gas cooler (Heat rejection air or water heat exchanger)
MT1: Compressor MT 1 (Compresses vapour from MT to high pressure side)
RIn: Intermediate pressure receiver (Refrigerant charge storage tank)
RMT: Receiver MT (MT booster receiver)
EMT: Evaporator MT (MT display cabinets and cold rooms)
LT1: Compressor LT 1 (Compresses vapour from LT to MT pressure side)
ELT: Evaporator LT (LT display cabinets and cold rooms)

Booster System – flash gas by-pass

MT:

gas cooler pressure: 90 bar
receiver pressure: 35 bar

- 4 compressors CD3500H

LT:

- 3 compressors CD1300M

COP: 1.72
Power consumption: 116 KW

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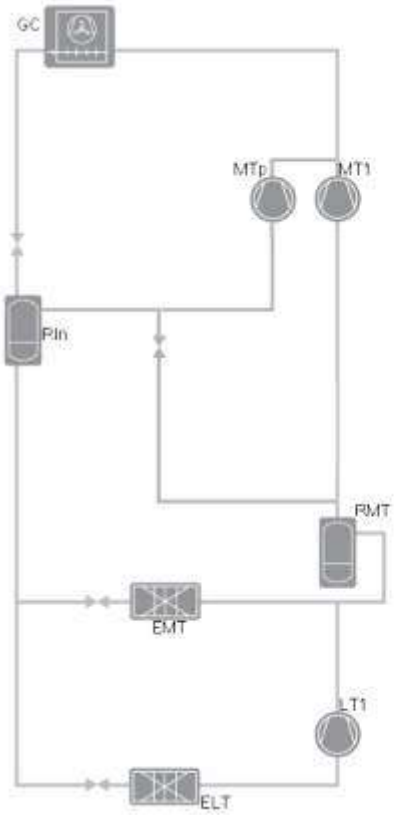
BOOSTER parallel compression – CO2



GC: Gas cooler (Heat rejection air or water heat exchanger)
MT1: Compressor MT 1 (Compresses vapour from MT to high pressure side)
MTp: Parallel compressor (Compresses vapour from Intermediate to high pressure side)
RIn: Intermediate pressure receiver (Refrigerant charge storage tank)
RMT: Receiver MT (MT booster receiver)
EMT: Evaporator MT (MT display cabinets and cold rooms)
LT1: Compressor LT 1 (Compresses vapour from LT to MT pressure side)
ELT: Evaporator LT (LT display cabinets and cold rooms)

Booster System – parallel compression

MT:

gas cooler pressure: 90 bar
receiver pressure: 35 bar

- 4 compressors CD2500M

Parallel Comp. CD3000H

LT:

- 3 compressors CDS501B

COP: 1.90
Power consumption: 105 KW

-3% energy

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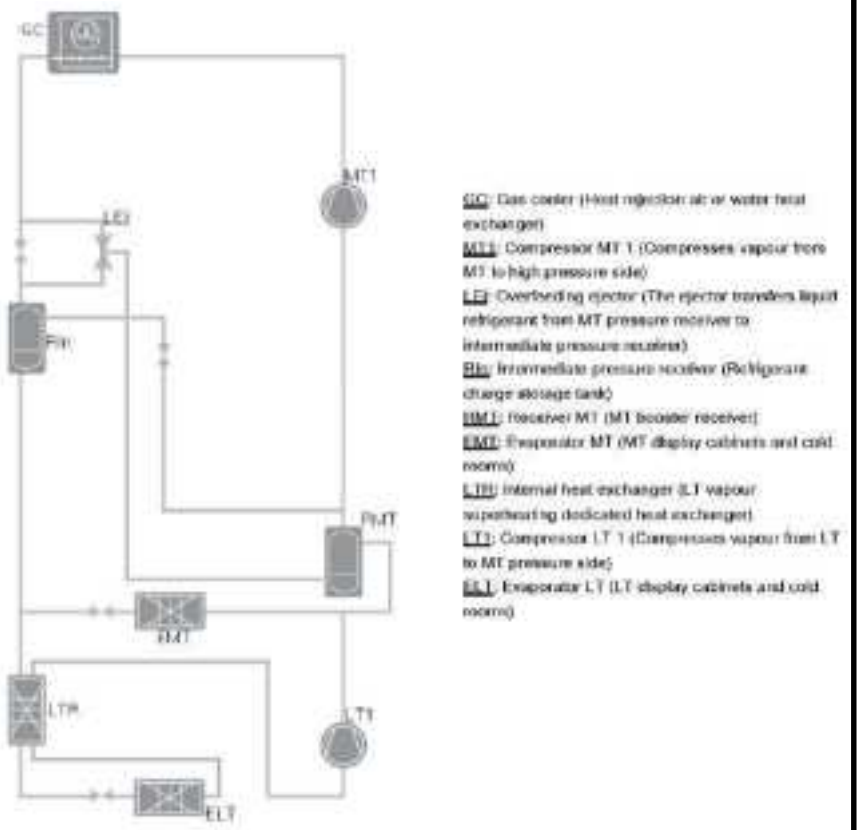
BOOSTER overfeeding ejector – CO2



GC: Gas cooler (Heat rejection air or water heat exchanger)
MT1: Compressor MT 1 (Compresses vapour from MT to high pressure side)
LEJ: Overfeeding ejector (The ejector transfers liquid refrigerant from MT pressure receiver to intermediate pressure receiver)
PIR: Intermediate pressure receiver (Refrigerant charge storage tank)
PIMT: Receiver MT (MT booster receiver)
EMT: Evaporator MT (MT display cabinets and cold rooms)
LTR: Internal heat exchanger (LT vapour superheating dedicated heat exchanger)
LT1: Compressor LT 1 (Compresses vapour from LT to MT pressure side)
ELT: Evaporator LT (LT display cabinets and cold rooms)

Booster System – overfeeding ejector

MT:

gas cooler pressure: 90 bar
receiver pressure: 35 bar

- 4 compressors CD3000M

LT:

- 3 compressors CDS401B

COP: 2.08
Power consumption: 96.11 KW

-12% energy

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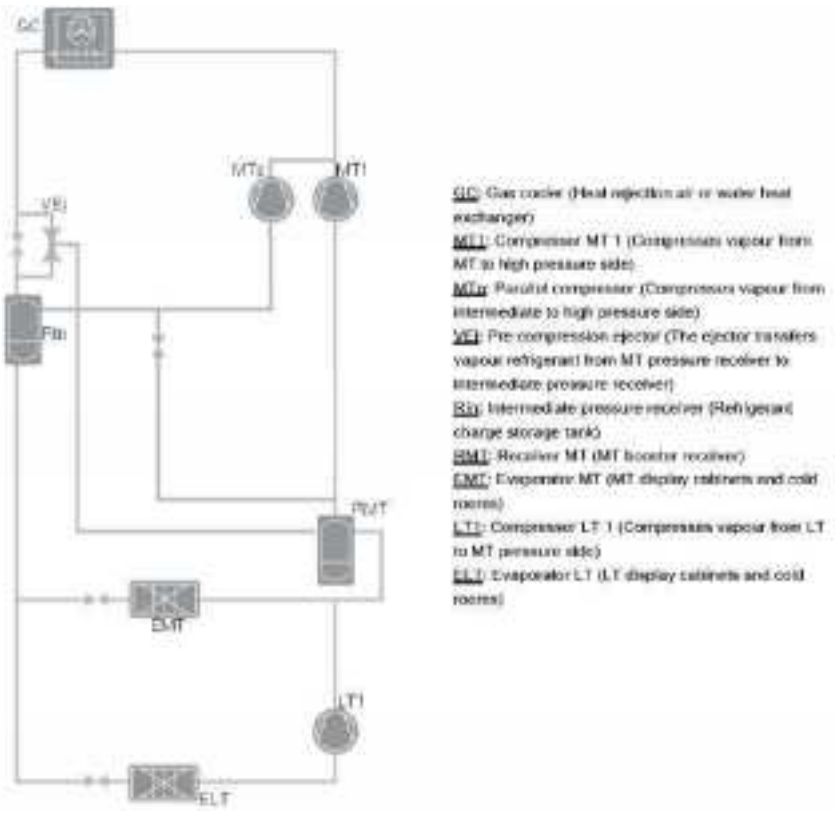
BOOSTER Pre-compression ejector



GC: Gas cooler (Heat rejection air or water heat exchanger)
MT1: Compressor MT 1 (Compresses vapour from MT to high pressure side)
MTp: Parallel compressor (Compresses vapour from intermediate to high pressure side)
VEI: Pre-compression ejector (The ejector transfers vapour refrigerant from MT pressure receiver to intermediate pressure receiver)
RIp: Intermediate pressure receiver (Refrigerant charge storage tank)
RMT: Receiver MT (MT booster receiver)
EMT: Evaporator MT (MT display cabinets and cold rooms)
LT1: Compressor LT 1 (Compresses vapour from LT to MT pressure side)
ELT: Evaporator LT (LT display cabinets and cold rooms)

Booster System
Pre-compression ejector

MT:

gas cooler pressure: 90 bar
receiver pressure: 35 bar

- 4 compressors CD2000M

Parallel Comp. CD4000H

LT:

- 3 compressors CD1300M

COP: 1.98
Power consumption: 101 KW

-7% energy

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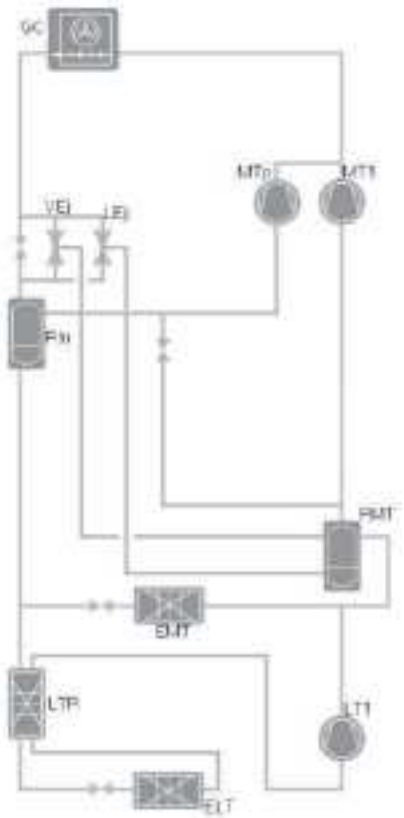
BOOSTER Overfeeding/Pre-compression ejector



GC: Gas cooler (Heat rejection air or water heat exchanger)
MT1: Compressor MT 1 (Compresses vapour from MT to high pressure side)
MTp: Parallel compressor (Compresses vapour from intermediate to high pressure side)
EI: Overfeeding ejector (The ejector translates liquid refrigerant from MT pressure receiver to intermediate pressure receiver)
VEI: Pre-compression ejector (The ejector transfers vapour refrigerant from MT pressure receiver to intermediate pressure receiver)
RIS: Intermediate pressure receiver (Refrigerant charge storage tank)
RMT: Receiver MT (MT booster receiver)
EMT: Evaporator MT (MT display cabinets and cold rooms)
LTR: Internal heat exchanger (LT vapour superheating dedicated heat exchanger)
LT1: Compressor LT 1 (Compresses vapour from LT to MT pressure side)
ELT: Evaporator LT (LT display cabinets and cold rooms)

Booster System – overfeeding/pre-compression ejector

MT:

gas cooler pressure: 90 bar
receiver pressure: 35 bar

- 4 compressors CD1400M

Parallel Comp. CD4000H

LT:- 3 compressors CDS401B

COP: 2.15
Power consumption: 93 KW

14% less energy!

Ing. Mauro Bonfanti

Case 2:

INDUSTRIAL REFRIGERATION (>500kWr)

Refrigerant and Refrigeration systems comparison

Ing. Mauro Bonfanti

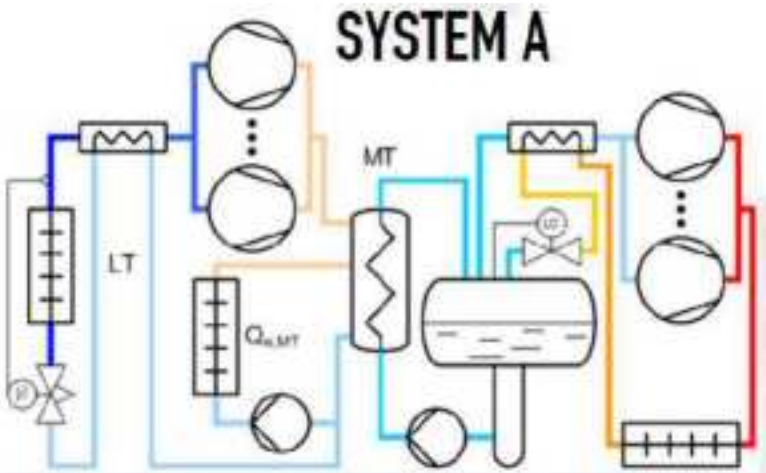
CO_2 vs NH_3

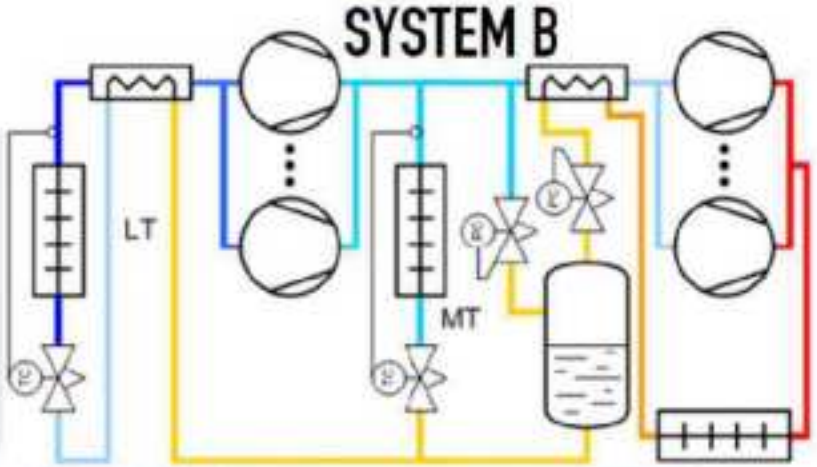
- **Energy consumption comparison - CO_2 and NH_3 – system features**
  - **250 kW LT capacity**
  - **500 kW MT capacity**
  - **No heat reclaim to be conservative**

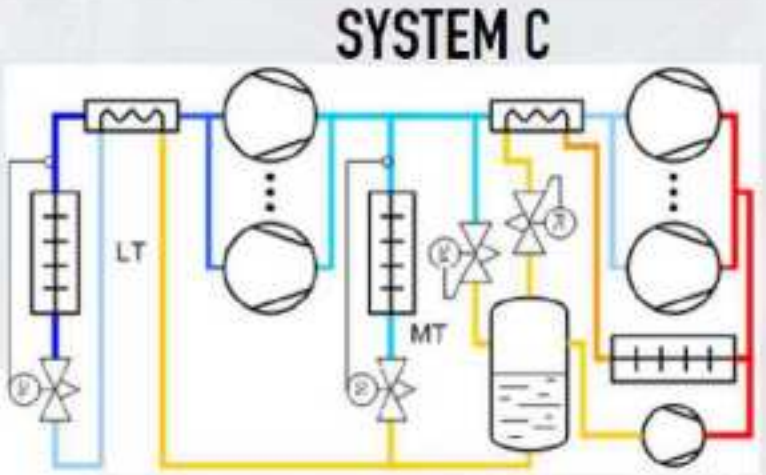
- **SYSTEM A:** CO_2 cascaded with NH3
- **SYSTEM B:** full CO_2 Booster – flash gas bypass (FGB)
- **SYSTEM C:** full CO_2 Booster – parallel compression (PC)

- **NH_3: minimum T_{cond} according to Bitzer OSKA range envelope**
- **CO_2: minimum T_{cond} according to Dorin CD range envelope**

CO_2 vs NH_3







- A: CO_2 CASCADED WITH NH_3
- B: CO_2 – FLASH GAS BYPASS (FGB)
- C: CO_2 – PARALLEL COMPRESSION (PC)

CO_2 vs NH_3

CO_2 (FGP: -22575 €)

CO_2 (FGP: -15547 €)

CO_2 (FGP: -15502 €)

CO_2 (PC: -625 €)

CO_2 (PC: -598 €)

CO_2 (PC: -307 €)

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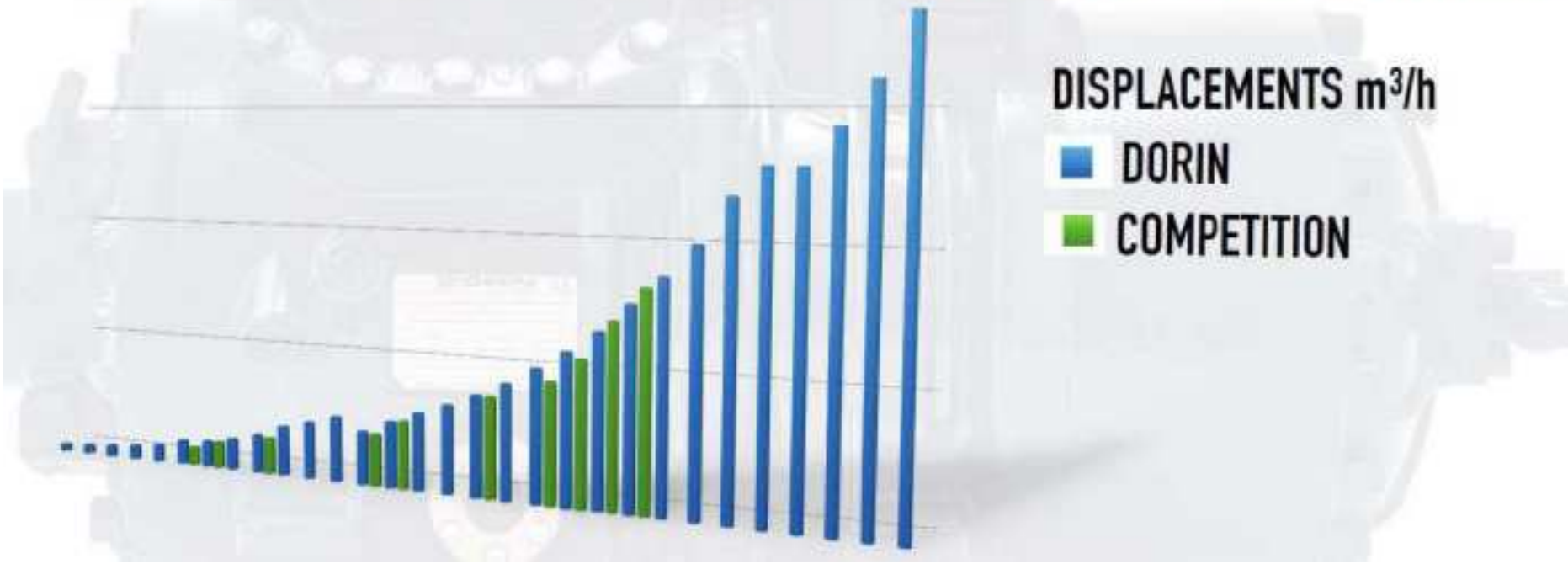
YEARLY ENERGY & COST COMPARISON: EUROPE

	NH_3	CO_2 FGP	CO_2 PC
STOCKHOLM - SWEDEN	REF	- 22575 €	- 25782 €
BERLIN - GERMANY	REF	- 15547 €	- 19918 €
MUNICH - GERMANY	REF	- 15502 €	- 19681 €
BARCELONA - SPAIN	REF	+ 4815 €	- 625 €
FLORENCE - ITALY	REF	+ 5108 €	- 598 €
ATHENS - GREECE	REF	+ 7819 €	- 307 €
- 0,06 € per kWh -			

CO_2 vs NH_3

- TOTAL MT CAPACITY: 850 kW
  - COMPETITION CO_2 COMPRESSORS
  - (30–38) m^3/h: 10–15 PIECES NEEDED
  - N.2 RACKS – EXPENSIVE SOLUTION
  - DORIN 6 CYL CO_2 RANGE – 60 m^3/h
  - 6 PIECES ONLY ARE NEEDED
  - N.1 RACK ONLY – SIMPLER SOLUTION



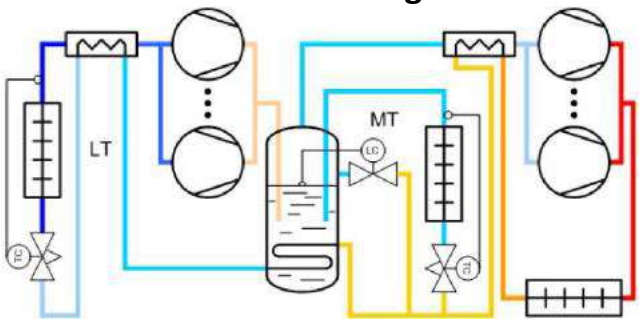
Future developments bringing solutions up to 100m³/h

CO_2 vs NH_3

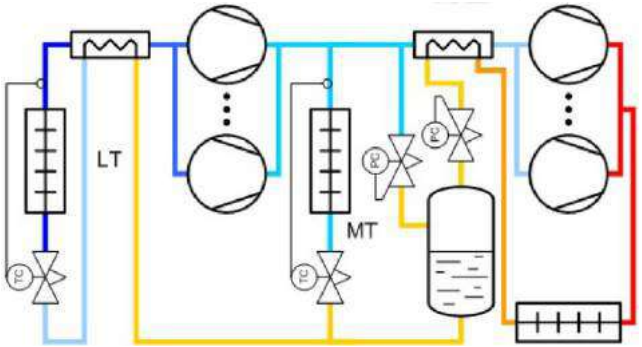
- F-gas REGULATION:
  - STRONG INFLUENCE IN THE EUROPEAN REFRIGERATION INDUSTRY
- NATURAL REFRIGERANTS:
  - THE BEST ALTERNATIVE FOR ALMOST ALL THE APPLICATIONS
- INDUSTRIAL APPLICATIONS
  - CO_2 IS APPROACHING THIS FIELD AGAINST AMMONIA
  - CO_2 PROVIDES SOME TECHNICAL & SAFETY ADVANTAGES
  - CO_2 CAN ALSO PROVIDE COST SAVINGS
  - DORIN 6 CYLINDERS TRANSCRITICAL COMPRESSORS UP TO 60 m^3/h ALLOW CO_2 TO APPROACH THE INDUSTRIAL MARKET IN AN EFFECTIVE WAY

Pack Calculation Pro – São Paulo

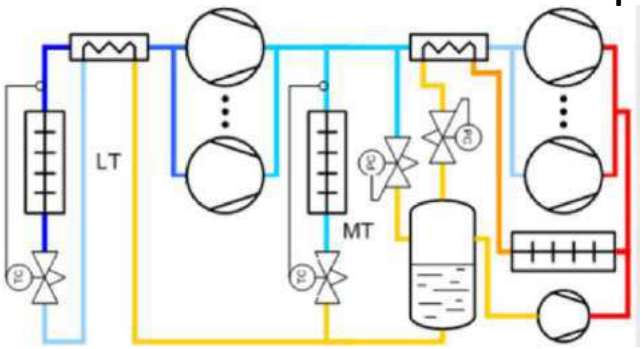
SYSTEM A: R717 - Two stage closed intercooler



SYSTEM B: R744 – Booster Flash gas bypass

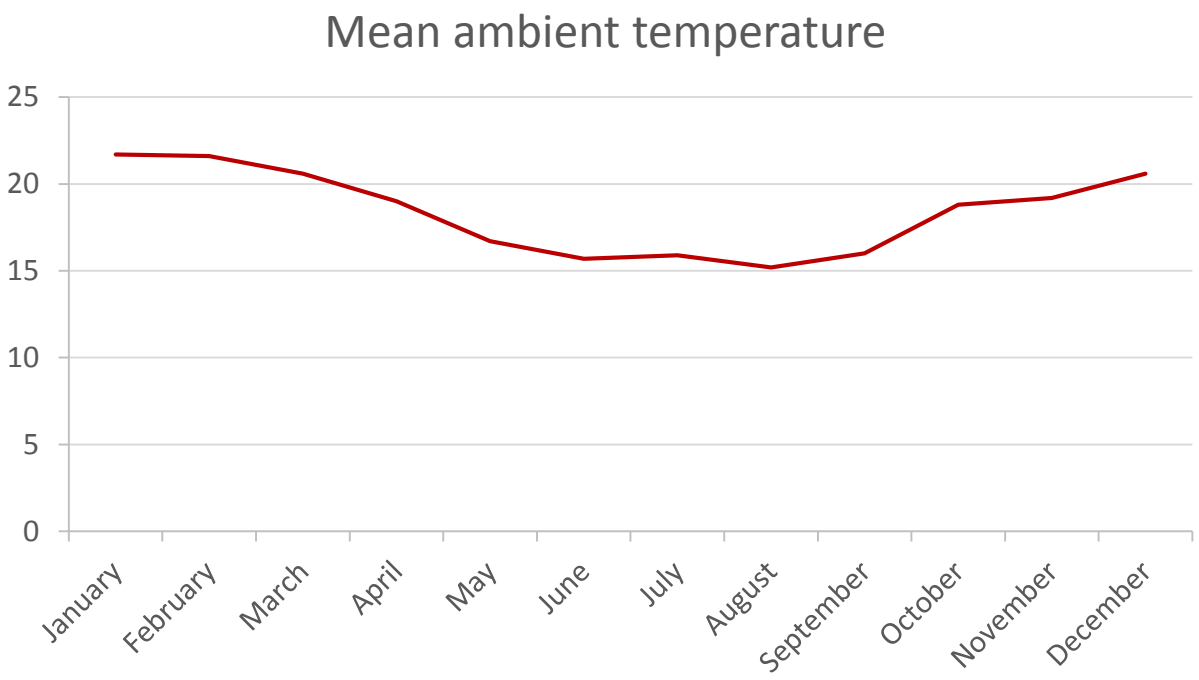


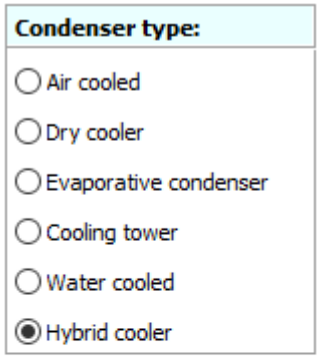
SYSTEM C: R744 – Booster Parallel compression

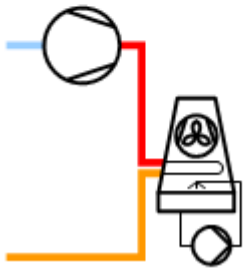


	MT -8° C [300 kW]	LT -28° C [400 kW]
SYSTEM A NH3 DX	N.2 OSKA8591 Bitzer screw	N.2 M series Mayekawa
SYSTEM B CO2 FGP	N.5 CD6 800 59 M Dorin	N.2 CDS 8 cyl Dorin
SYSTEM C CO2 PC	N.4 CD6 800 53 M N.2 CD4501H Dorin	N.2 CDS 8 cyl Dorin

Pack Calculation Pro – São Paulo

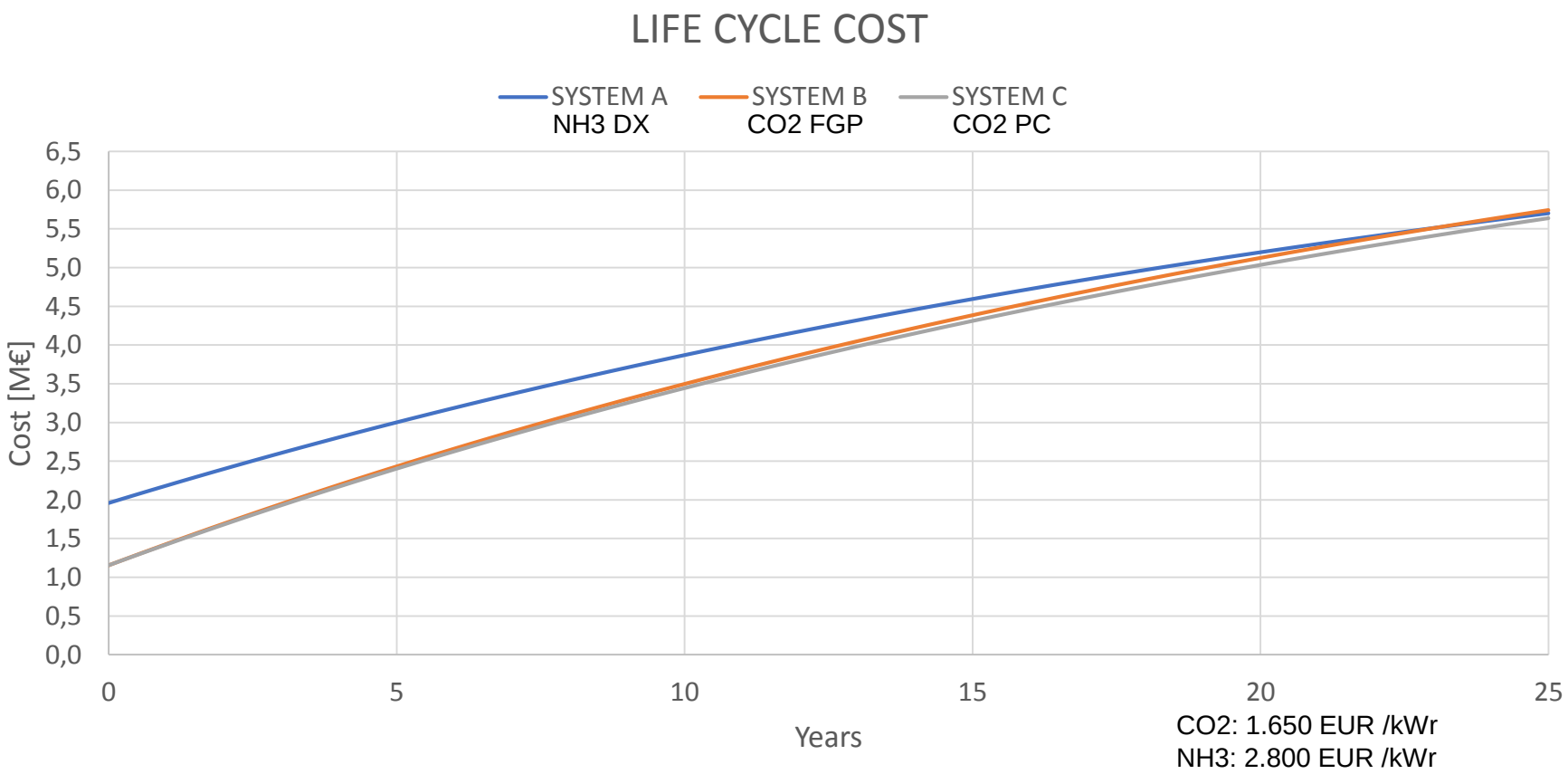






- Minimum T_{cond} according to compressors envelope
- Subcooling condenser MT: 2K
- Delta T condenser: 10 K [R717], 7 K [R744]
- No heat reclaim to be conservative

Pack Calculation Pro – São Paulo



AVERAGED INTEREST RATE	AVERAGED INFLATION RATE	AVERAGED ENERY COST	LIFETIME
6,5 %	2,7 %	0,1 [€/kWh]	25 years

CO2 is an economic solution throughout the installation lifecycle, with lower capital investment and no/low concern on safety

Double stage vs. screw

- NEW PRODUCTS - NEW NICHES
- 2S-H7 RANGE: COMPETING WITH SCREW COMPRESSORS

- LARGE LT APPLICATIONS
  - MARKET IS DOMINATED BY SCREWS
  - BRAND NEW NICHE FOR DORIN

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PRODUCT RANGE

CD series

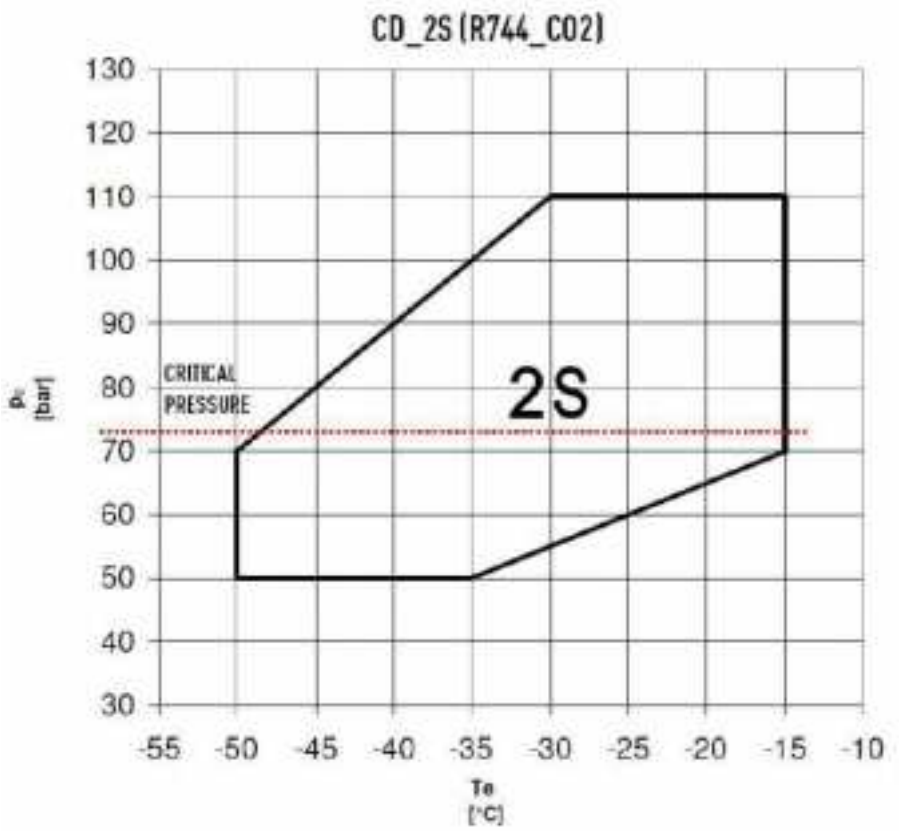
- Pss = 100 bar - PS = 150 bar
- Wide application envelope: from 1,12 m^3/h to 82,00 m^3/h
- Booster applications
- HP and LP safety relief valve
- Suitable for low (B range), medium (M range) and high (H range up to +15°C) evaporation temperature
- Low vibrations, thanks to an optimized mass balance
- Low gas pulsation
- Suitable for frequency control

CD600 series

Range Serie	Model Typ	Displacement Fördervolumen	Cylinders Zylinder	Oil charge Ölfüllung	Suction Saugventil	Discharge Druckventil	Net weight Nettogewicht
		50 Hz [m^3/h]		[kg]	SL [mm]	DL [mm]	[kg]
CD 600	CD6 1200-58H	57,65	6	4,5	54	42	444
	CD6 1200-64M	64,49	6	4,5	54	42	443
	CD6 1400-64H	64,49	6	4,5	54	42	461
	CD6 1400-72M	71,72	6	4,5	54	42	461
	CD6 1600-72H	71,72	6	4,5	54	42	477
	CD6 1600-82M	81,95	6	4,5	54	42	476

- 6 cylinder solution for transcritical application
- Largest refrigeration capacity range of compressors ever available nowadays on the market

CO_2 compressor 2 stage transcritical



- Dorin is the only producer of 2 stage transcritical CO_2 compressors from **3 HP** to **35 HP**
- P_{ss} = 100 bar, P_s = 150 bar
- Excellent for CO_2 condensing unit [1 ÷ 40 kW @-30°C / 90bar / 30°C T_{GCout}]

HEX series

- Displacement from *4,42* m^3/h to *244,78* m^3/h
- 86 models from *0,5* HP to *90* HP suitable for low, medium and high temperature
- II 3Gc Ex nA IIB T3 Gc classification
- Solutions:
  - Electric box 7J Shock proof
  - Oil sight glass 2J Shock proof
  - ATEX approved oil differential pressure switch
- Standard accessories:
  - crankcase heater
  - maximum discharge temperature sensor

Open type series

- **Displacement @1450 rpm *2,37* m^3/h to *250,73* m^3/h for open type compressor**

- **Open type compressor for transport application**
- **Fully interchangeable with other compressor brands**
- **Aluminium crankcase**
- **Only 6 kg weight for the 2 cylinders model**

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