Officine Mario Dorin S.p.A.

The New F-GAS Regulations forceTo Look for New Solutions for Refrigeration and H/Pumps Systems

DORIN is ready to offer a wide range of State-of-Art Compressors

Massimo Casini

China Refrigeration 2014

Beijing April 10°, 2014

1. OFFICINE MARIO DORIN: GENERAL OVERVIEW

- ➔ **Company founded in 1918**
- ➔ **First open type compressor for CFC: 1932**
- ➔ **First Semi-hermetic compressor for CFC: 1952**
- ➔ **Helium leak test since 1980**
- ➔ **Sling disk lubrication up to 20 hp since 1985**
- ➔ **Inverter drive since 1990**
- ➔ **CO_2 trans-critical compressors since 1995**
- ➔ **4 facilities located in Firenze – Italia**
- ➔ **1 facility in Shanghai, China**
- ➔ **250 employees**
- ➔ **to date: more than 12.000 CO_2 compressors already commissioned**
- ➔ **volumes: 60.000 HFC compressors (CO_2 sub-critical)**
  2.500 Trans-critical CO_2 compressors
  5000 condensing units

1. OFFICINE MARIO DORIN: GENERAL OVERVIEW

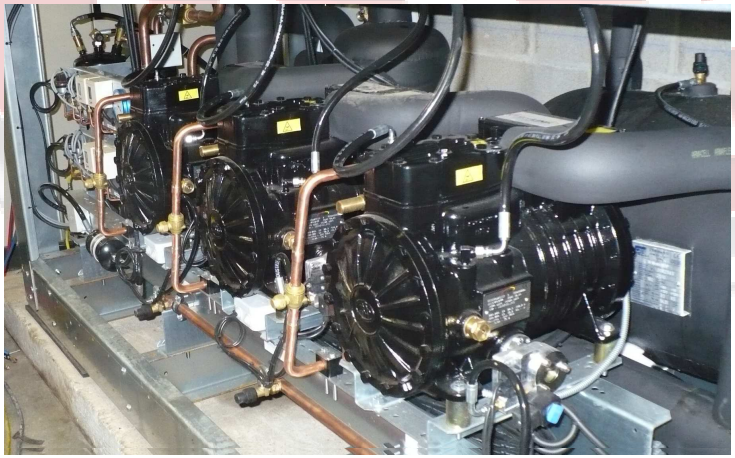
DORIN COMPRESSORS: REFERENCE LIST

- ➔ **RACK (RETAIL) BUSINESS**
- ➔ **RAILWAY BUSINESS**
- ➔ **INDUSTRIAL / OIL & GAS**
- ➔ **MARINE / OFF-SHORE**
- ➔ **HOT WATER HEAT PUMPS**
- ➔ **ICE-SKATE ARENA**
- ➔ **ICE-CREAM INDUSTRY**
- ➔ **WHOLESALE NETWORk**

2. DORIN COMPRESSORS: REFERENCE LIST

➔ **RACK (RETAIL) BUSINESS**

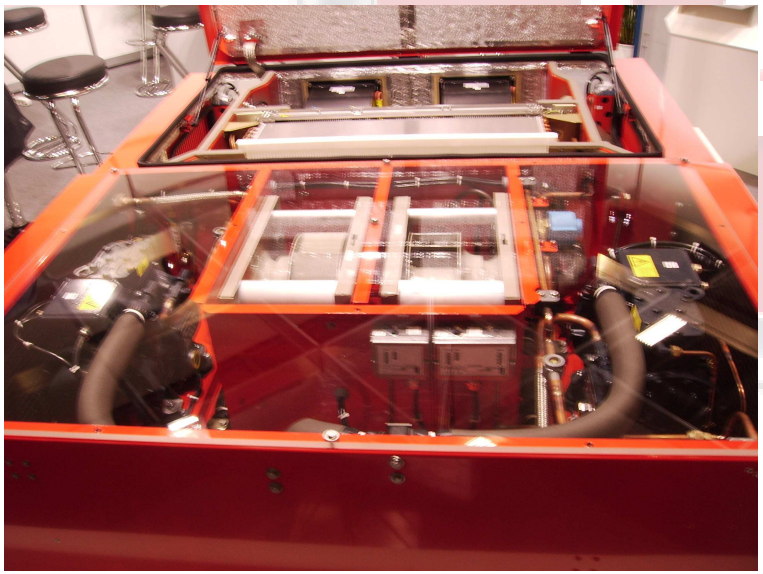
- **GREEN & COOL - SE**
- **HILL PHOENIX - US**
- **ADVANSOR - DK**
- **RIVACOLD - IT**
- **ARNEG - IT**
- **COSTAN - IT**
- **HEATCRAFT - AU**
- **ZANOTTI - IT**
- **HUURRE - FI**
- **ENEX - IT**
- **SCM FRIGO - IT**
- **…**

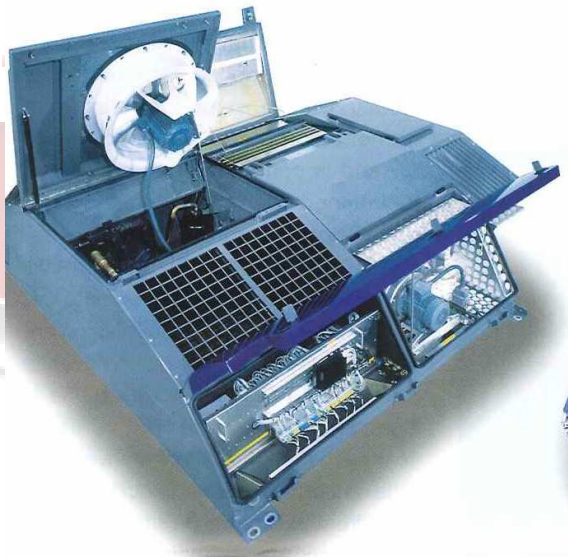


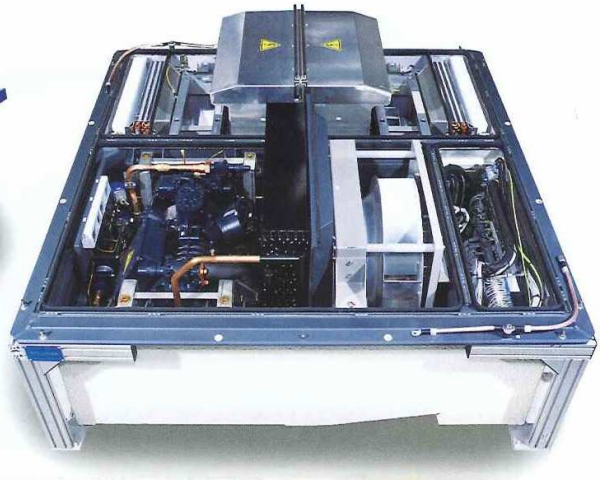
2. DORIN COMPRESSORS: REFERENCE LIST

➔ **RAILWAY BUSINESS**

- **FAIVELEY - DE**
- **LIEBHERR - OS**
- **MERAK - SP**
- **REXXON - DE**
- **KLIMAT-FER - IT**
- **…**



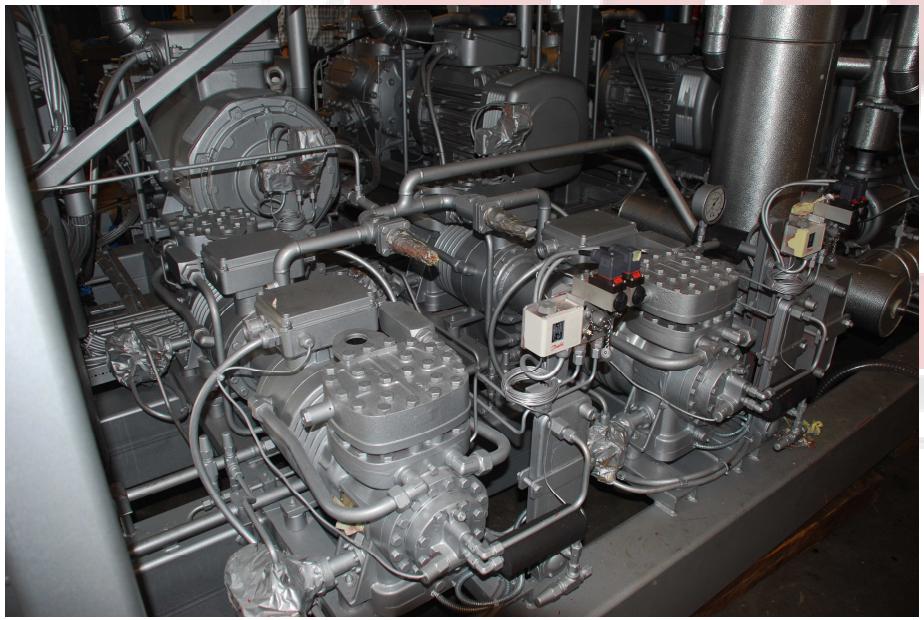


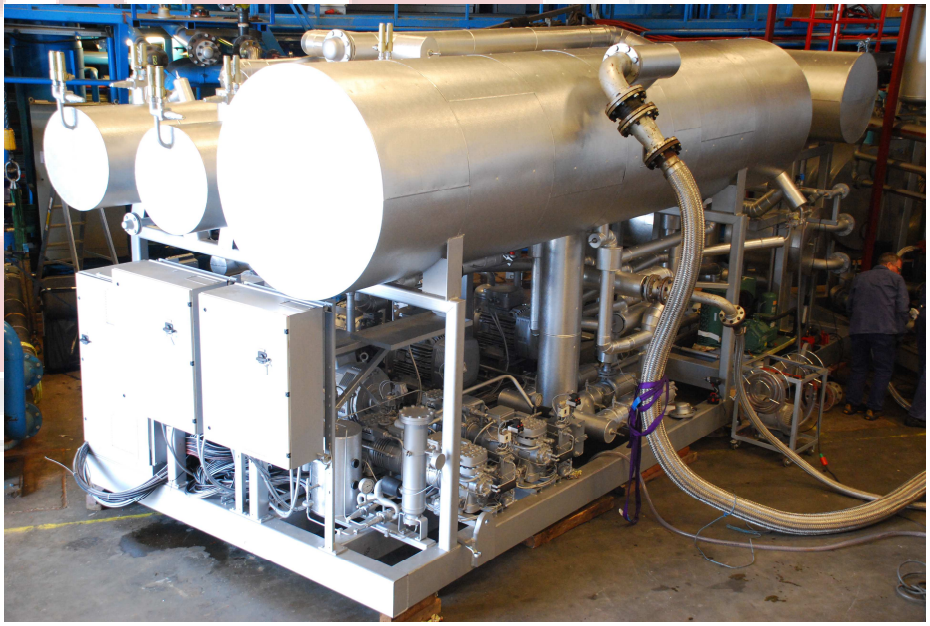


2. DORIN COMPRESSORS: REFERENCE LIST

➔ **INDUSTRIAL/OIL & GAS**

- **JOHNSON CONTROL - DK**
- **MASKIN INDUSTRITEK - NO**
- **ANGELANTONI - IT**
- **FRIGEL - IT**
- **…**



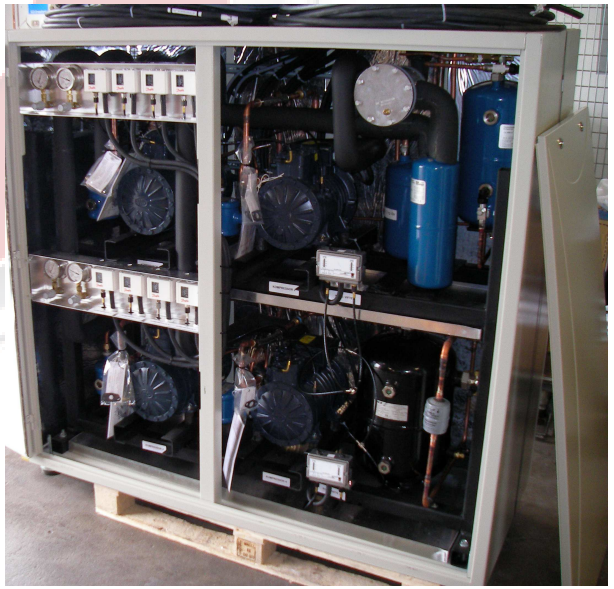


2. DORIN COMPRESSORS: REFERENCE LIST

OFFICINE MARIO DORIN SINCE 1918
DORIN INNOVATION

➔ **MARINE APPLICATIONS**

- **MASKIN-INDUSTRITEKNIKK - NO**
- **KULDETENKNISK - NO**
- **ITALIAN NAVY - IT**
- **NORWEGIAN NAVY - NO**
- **…**



2. DORIN COMPRESSORS: REFERENCE LIST

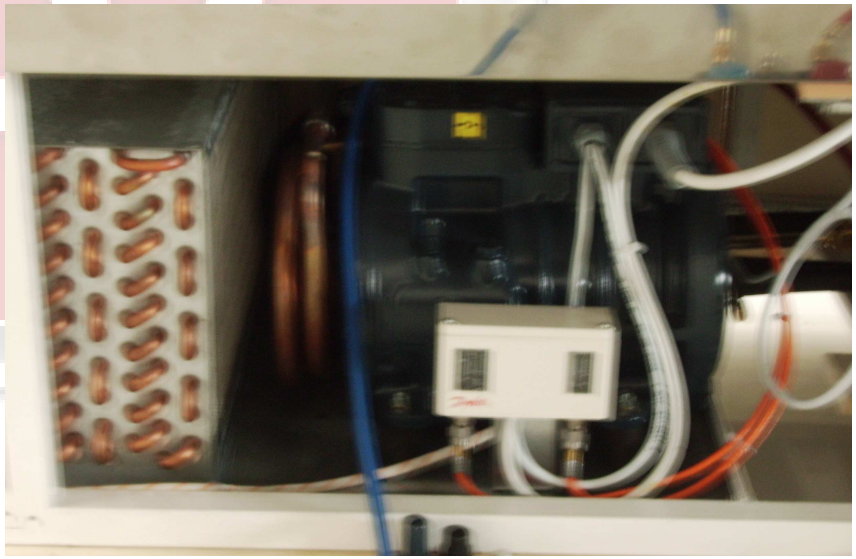
➔ **HOT WATER HEAT PUMPS**

- **ITOMIC - JP**
- **QUANTUM - CN**
- **DONGQI – CN**
- **NAMJI – KR**
- **YUNG SUNG – TW**
- **ENEX – ITA**
- **THERMOCOLD - ITA**
- **ENERBLUE – ITA**
- **…**

2. DORIN COMPRESSORS: REFERENCE LIST

➔ **ICE-CREAM INDUSTRY**

- **CARPIGIANI - IT**
- **BRAVO - IT**
- **GEL-MATIC - IT**
- **FRIGOMAT - IT**
- **ISA - IT**
- **…**



2. DORIN COMPRESSORS: REFERENCE LIST

➔ **ICE-SKATE ARENA**

- **ADVANSOR - DK**
- **SMARTREF – CA**
- **HILL PHOENIX - US**
- **…**

2. DORIN COMPRESSORS: REFERENCE LIST

➔ **WHOLESALE: PARTNERS IN MORE THAN 90 COUNTRIES**

➔ **LEADING WHOLESALERS**

➔ F-gas REGULATION

HFC BANDED

SEVERAL CONSTRAINTS INCOMING

DIFFERENT SOLUTIONS FOR DIFFERENT APPLICATIONS

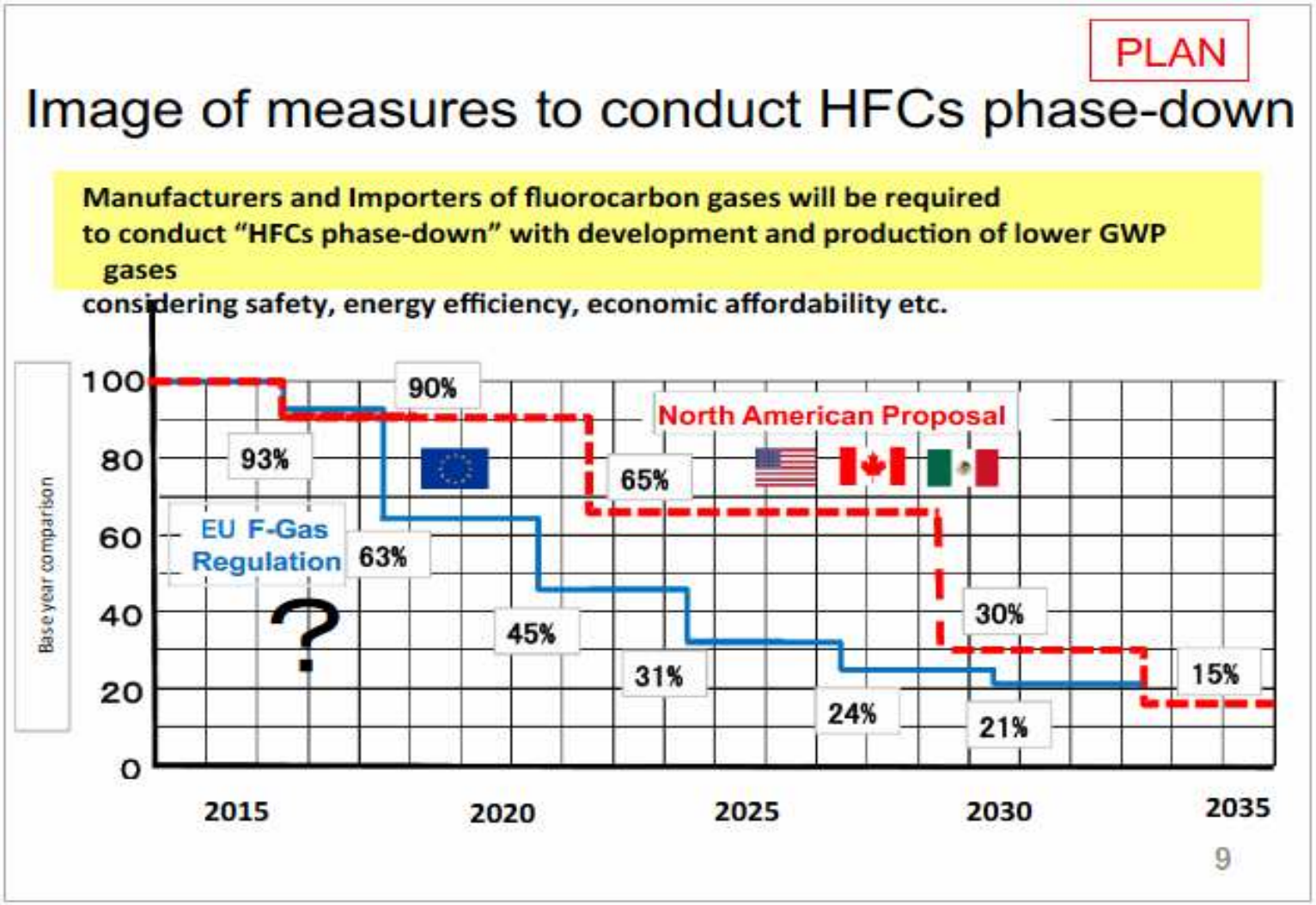
➔ENERGY SAVING

SYSTEM EFFICIENCY

OPTIMIZATION OF PARTIAL LOAD IS BECOMING MORE AND MORE IMPORTANT

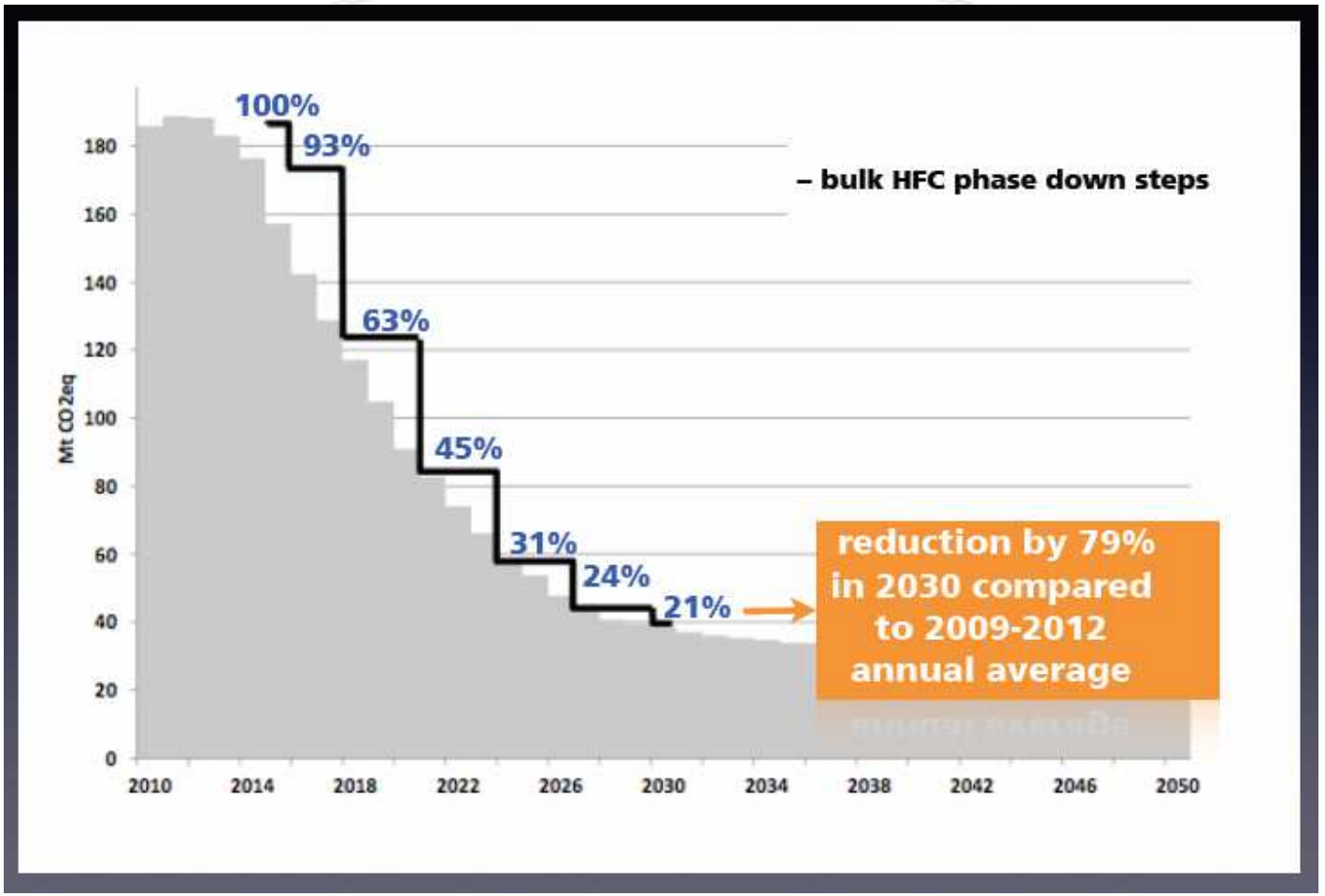
it makes no sense to use low GWP refrigerant if we create more co2 to drive the system

F-Gas Proposal in the World



3. F-gas REGULATION

EU F-Gas II

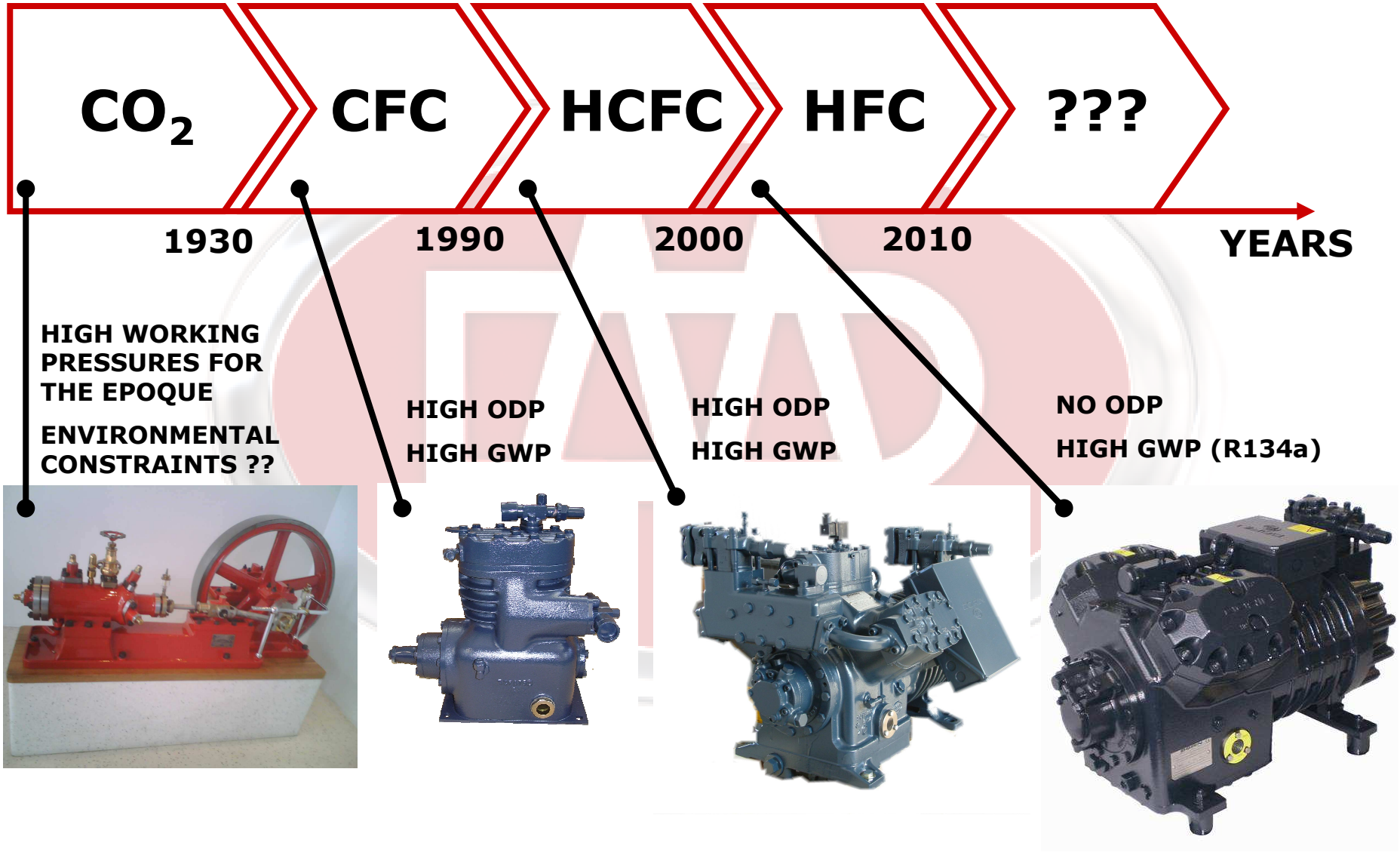


3. F-gas REGULATION

EU F-Gas II

	SECTOR (SUB-SECTOR)	informal F-Gas deal (Dec 2013)	
		GWP limit	As of (year)
1	Domestic refrigeration	150	2015
2	Refrigerators and freezers (hermetically sealed) for commercial use	2.500	2020
		150	2022
3	Movable room AC (hermetically sealed)	150	2020
4	Stationary refrigeration, except equipment intended for application design to cool products to temperatures below -50°C	2.500	2020
5	Multipack **centralised commercial refrigeration** systems with capacity≥40kW that contain f-gases with GWP≥150, except in the primary refrigerant circuit of cascade systems where f-gases with a GWP<1500 may be used	150	2022
6	Single split AC systems containing less than 3kg of f-gases	750	2025

3. F-gas REGULATION



3. F-gas REGULATION

HFC **???**

OTHER HFCs, NEW BLENDS:

- ➔ **R32 FLAMMABILITY SUPPRESSION**
- ➔ **R407A-F, GWP=2100/1800** (R404A – GWP=3900)
- ☺ **LOWER GWP**
- ☹ **LARGE TEMPERATURE GLIDE (ABOVE 6)**
- ☹ **HIGH POLYTROPHYC COEFFICIENT**

NATURAL REFRIGERANTS:

- ➔ **R744 (CO_2)**
- ➔ **R290 – R1270 (PROPANE, PROPYLENE)**
- ➔ **R717 (NH_3 – AMMONIA)**

NEW REFRIGERANTS, HFOs:

- ➔ **STRONG CHALLANGE IMPOSED BY MAC**
- ➔ **MILDLY FLAMMABLE (A2L – ASHRAE)**

3. F-gas REGULATION

HFC **CO2**

NATURAL REFRIGERANTS:

R744 (CO2)

R290 – R1270 (PROPANE, PROPYLENE)

R717 (NH3 – AMMONIA)

DORIN SOLUTIONS

- **CD CD2S CDS range for R744**
- *HEX range for R290 and R1270*
- *OPEN DRIVE COMPRESSORS DEDICATED TO AMMONIA APPLICATION*

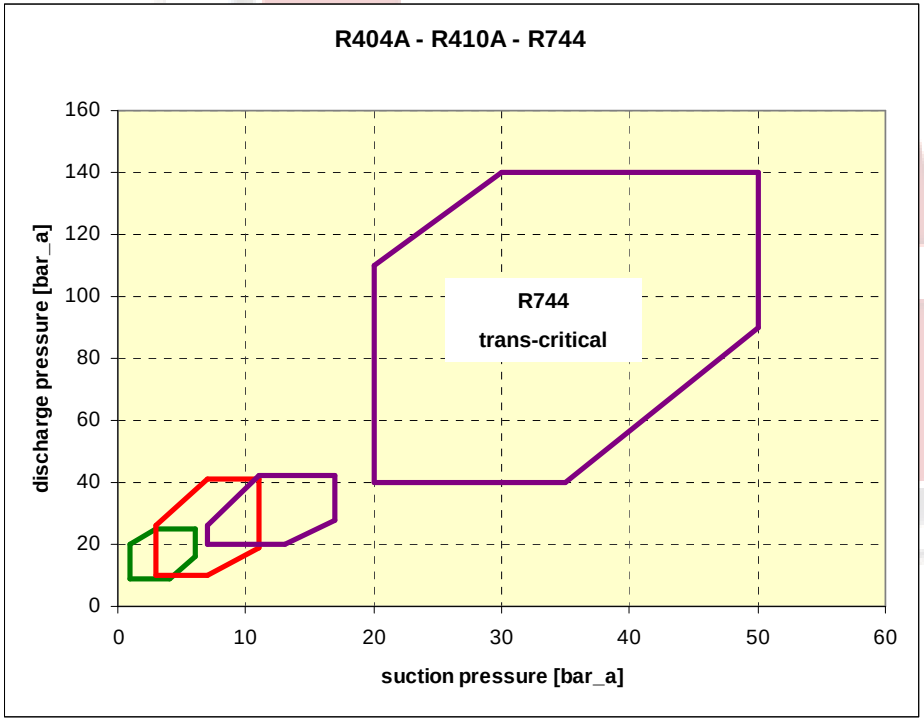
CO_2 Compressors

➔ **Design features**

➔ **Trans-critical Applications**

Much higher stress

Adaptation to standard HFC technology not possible



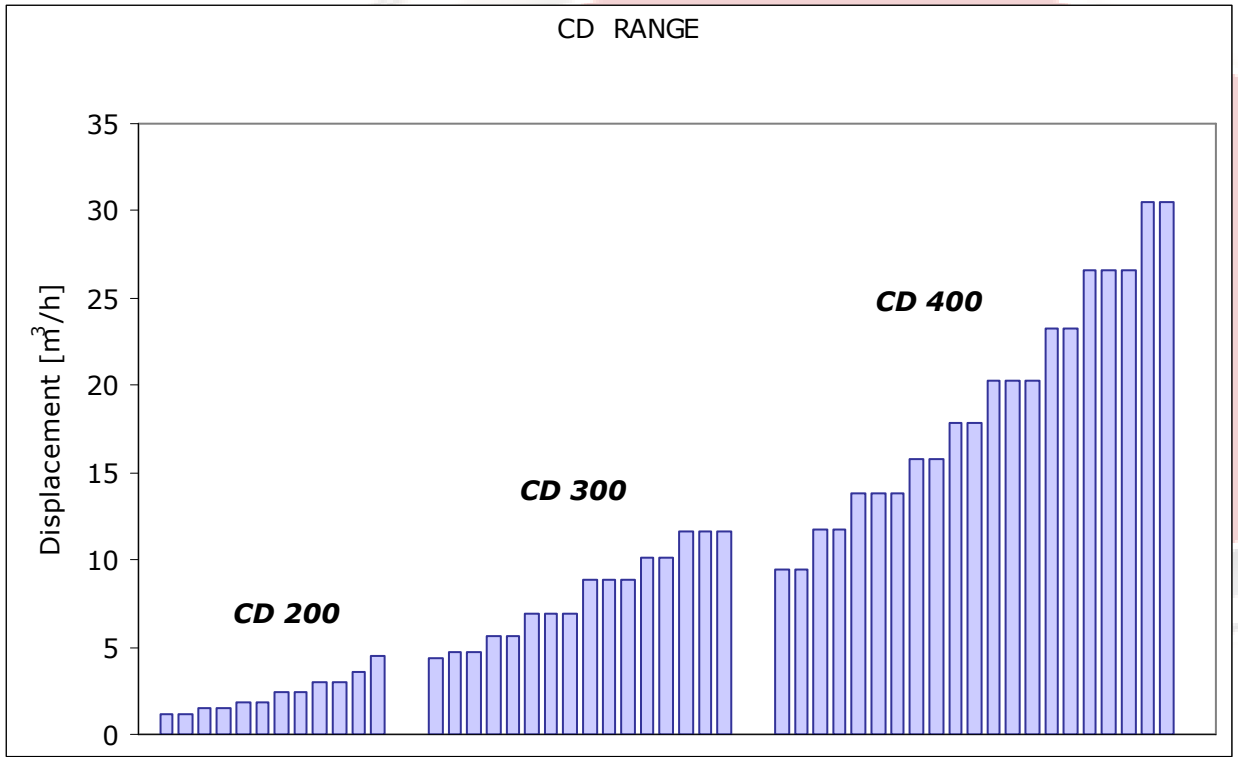
- ✓ **HP up to 160 bar_a**
- ✓ **LP up to 100 bar_a (standstill)**
- ✓ **consistently higher delta_P**
- ✓ **platform design from "scratch"**
- ✓ **several key issues**

3. F-gas REGULATION

➔ **Compressor Ranges: TRANSCRITICAL MODELS**

➔ **Launch of new compressor ranges: CD 200 - CD 300 - CD 400**

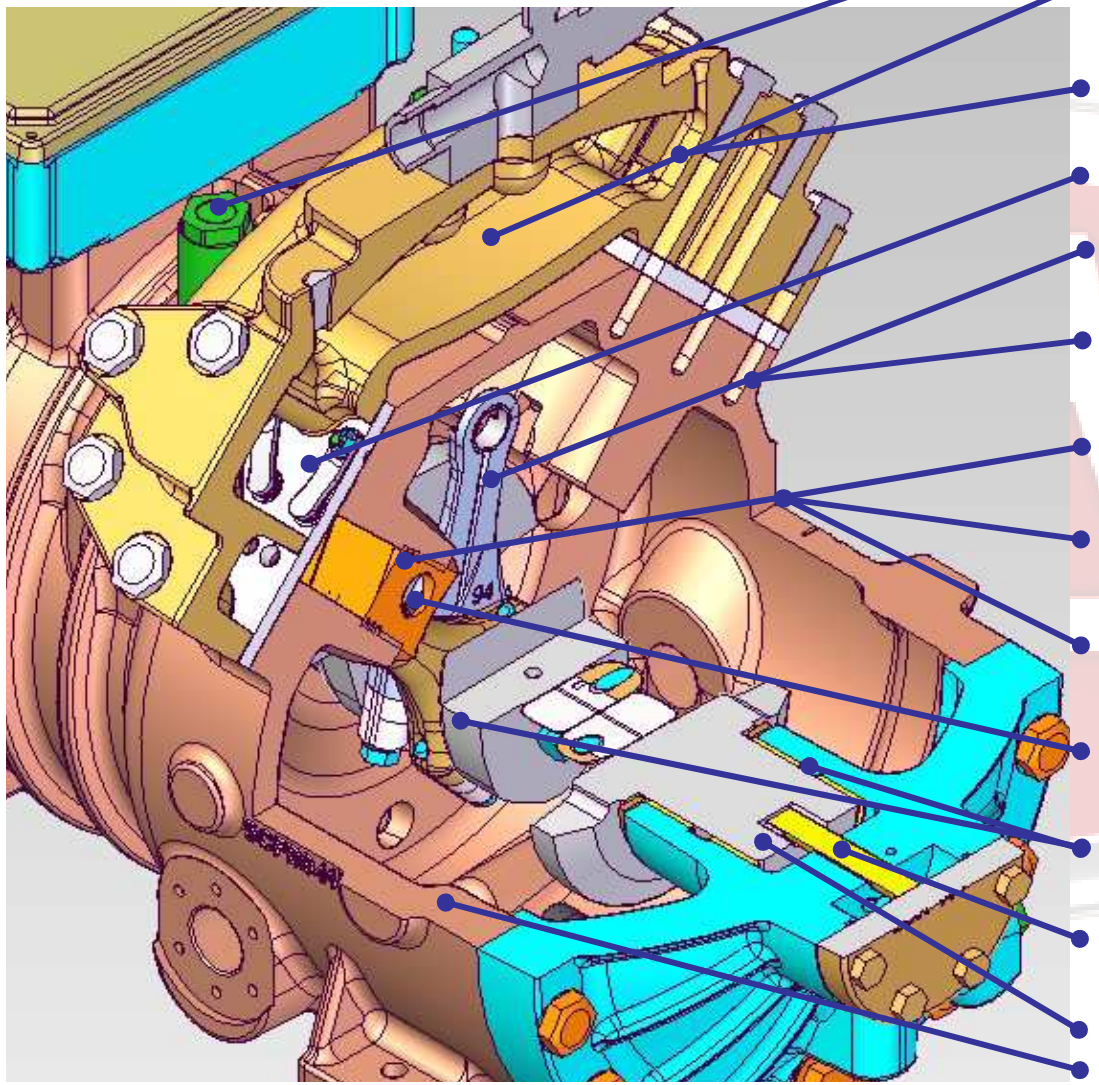
➔ **The widest CO_2 compressor range available in the market**



➔ **Displacements ranging from 1.1 m³/h to 30.5 m³/h**

➔ **Motor power ranging from 1.5 hp to 50 hp**

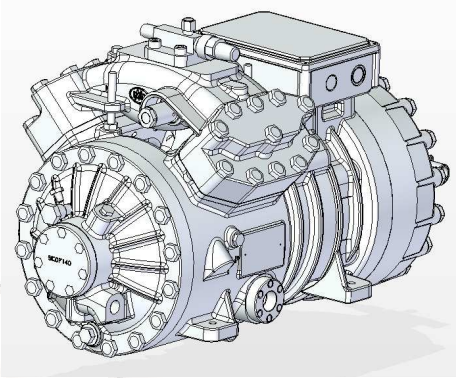
3. F-gas REGULATION



- LP & HP SRVs for safe operation
- External discharge manifold for adequate compression heat rejection
- Large discharge plenum for smooth operation and extra-low pressure pulses
- Efficient and robust valve plate design
- Double shell generous con rod design made of high strength material
- Specific oil stream passages to assure correct lubrication up to the small end
- Specially coated iron piston for proper behavior during hot operation
- Machined piston top for higher volumetric efficiencies
- Triple sealing assembly for excellent performances
- Specially coated wrist pin for proper strength and low friction coefficient
- Multi-layer low friction self-lubricating bearings for main and con rods big ends
- Forced lubrication via robust multi-gear oil pump
- Generous shaft drive with specific tribology
- Extra-tensile cast iron

3. F-gas REGULATION

OFFICINE MARIO DORIN SINCE 1918
DORIN INNOVATION

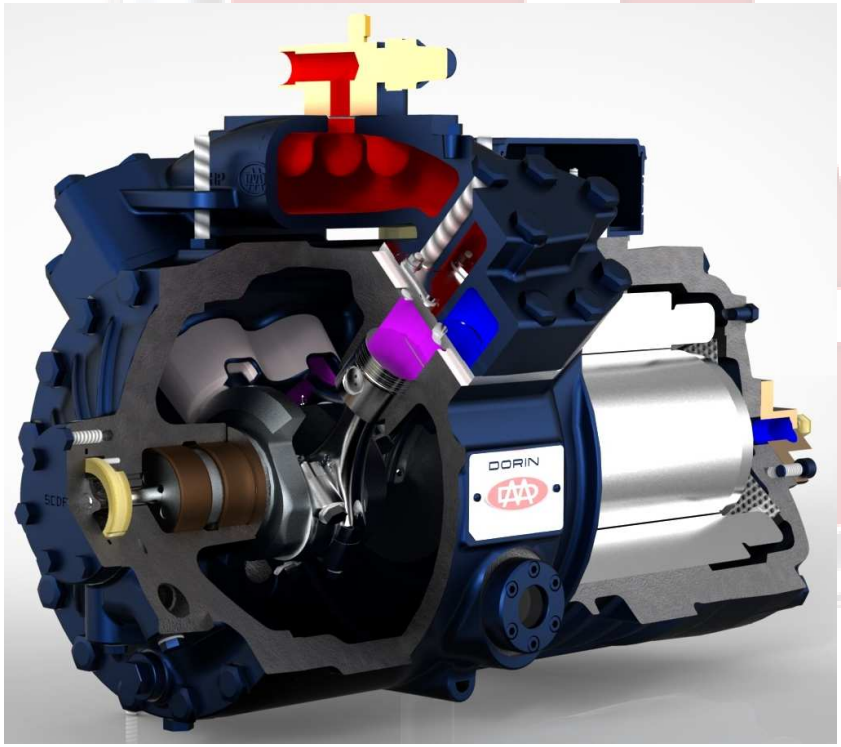


➔ **Compressor Ranges: TRANSCRITICAL MODELS**

➔ **CD 200 - CD 300 - CD 400**

➔ **Peculiar compressor design**

➔ **Increase of compressor efficiency**



- ✓ **HP / LP thermal insulation**
- ✓ **Lower discharge temperature**
- ✓ **Better lubrication**
- ✓ **Isentropic efficiency increase**

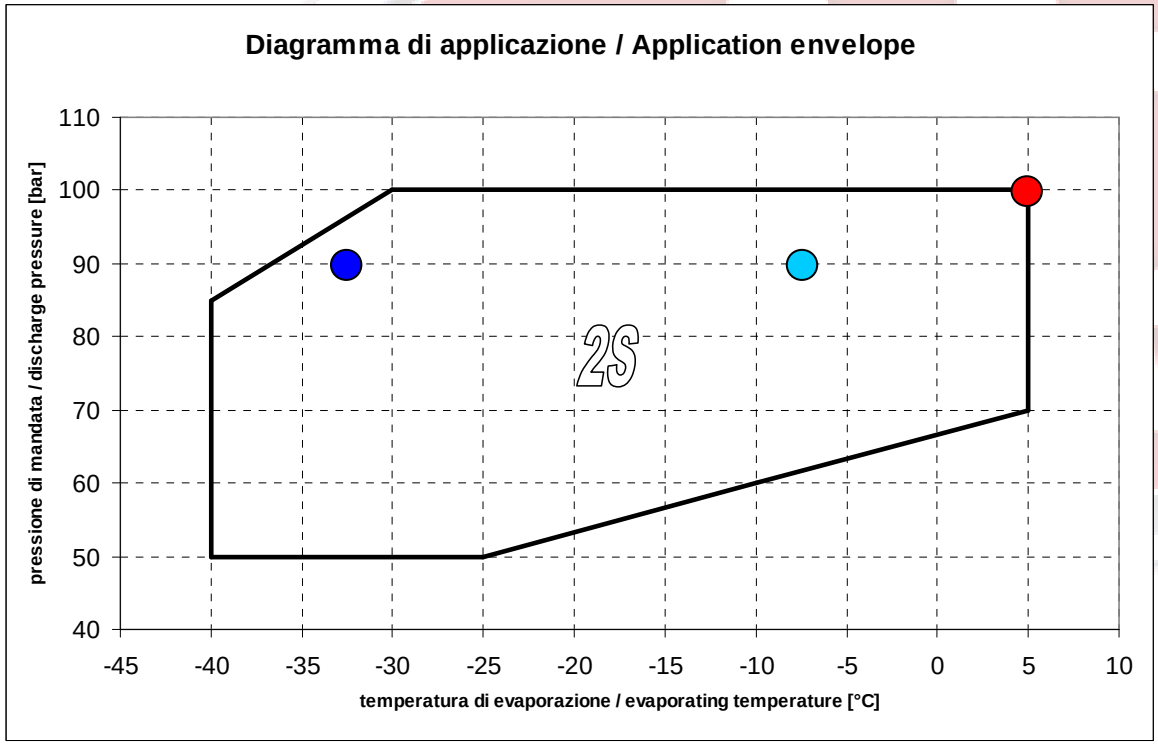
➔ **HIGHER RELIABILITY**

➔ **HIGHER EFFICIENCY**

3. F-gas REGULATION

➔ DOUBLE STAGE RANGE

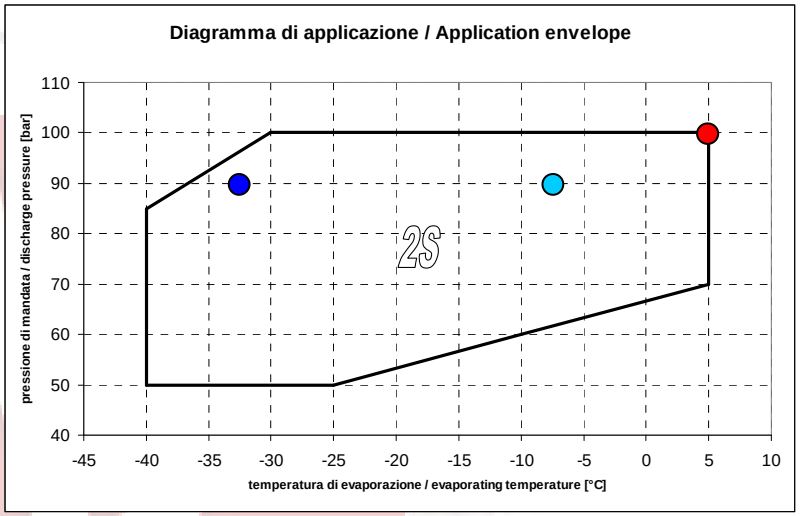
- ➔ **INTERNAL COMPOUND DESIGN**
- ➔ **Pss = 100, PS = 160 bar**
- ➔ **WIDE APPLICATION ENVELOPE**



- **LT OPERATION**
- **MT OPERATION**
- **HP OPERATION**

3. F-gas REGULATION

➔ DOUBLE STAGE RANGE



LT OPERATION

- ➔ SEPARATED HT AND LT PACKS, LESS RISKS
- ➔ FLOATING HEAD PRESSURE DEPENDING ON AMBIENT TEMPERATURE
- ➔ HIGH STANDSTILL PRESSURE (Pss = 100 bar)

MT OPERATION

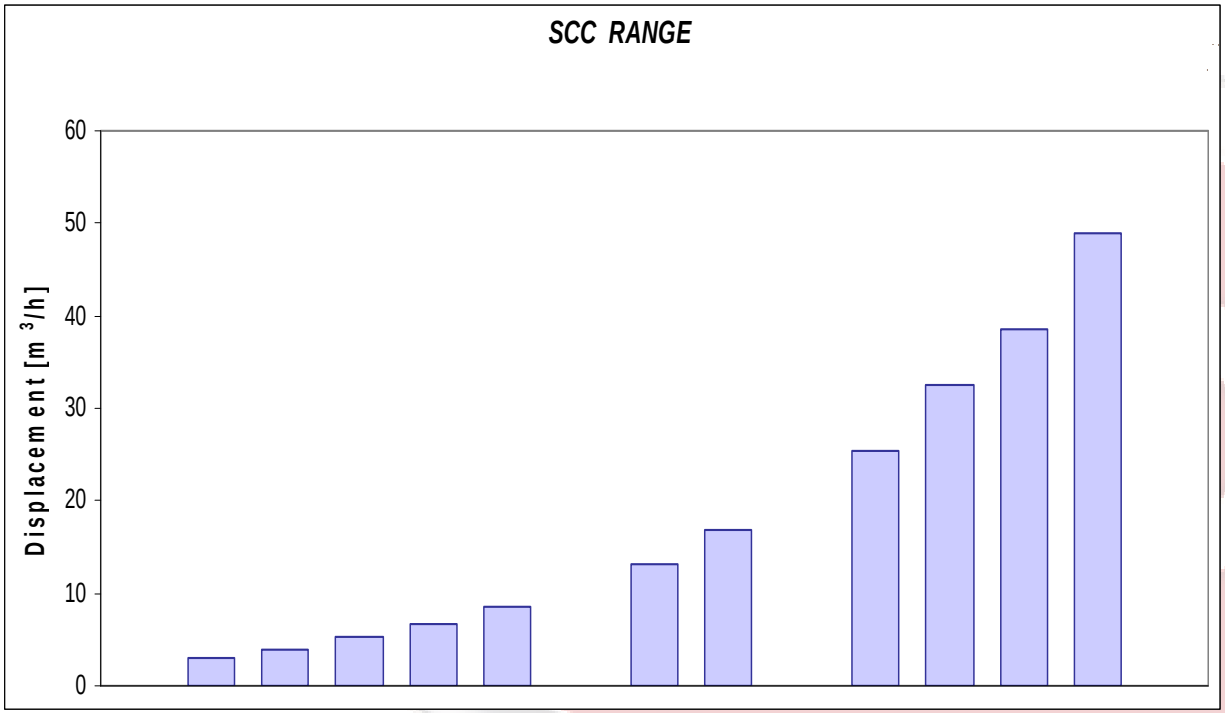
- ➔ LARGER SUBCOOLING EFFECT AVAILABLE
- ➔ COP BOOST, ESPECIALLY FOR WARMER CLIMATES

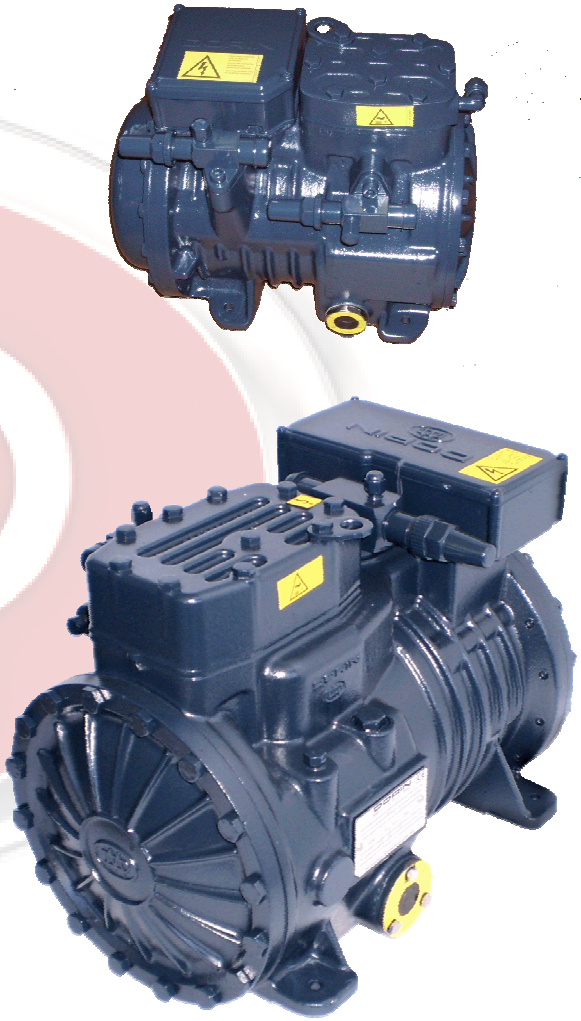
HP OPERATION

- ➔ CAPABILITY TO WORK AT POSITIVE EVAPORATING TEMPERATURES
- ➔ CAPABILITY TO WORK AT NEGATIVE EVAPORATING TEMPERATURES
- ➔ TOLERANT EXTREME UNDER-VOLTAGE AT -35°C – UP TO 400V 75Hz
- ➔ CAPACITY LOSS DUE TO LOWER EVAPORATING TEMPERATURES ARE BALANCED BY FREQUENCY INCREASE

3. F-gas REGULATION

➔ Compressor Ranges: SUBCRITICAL MODELS



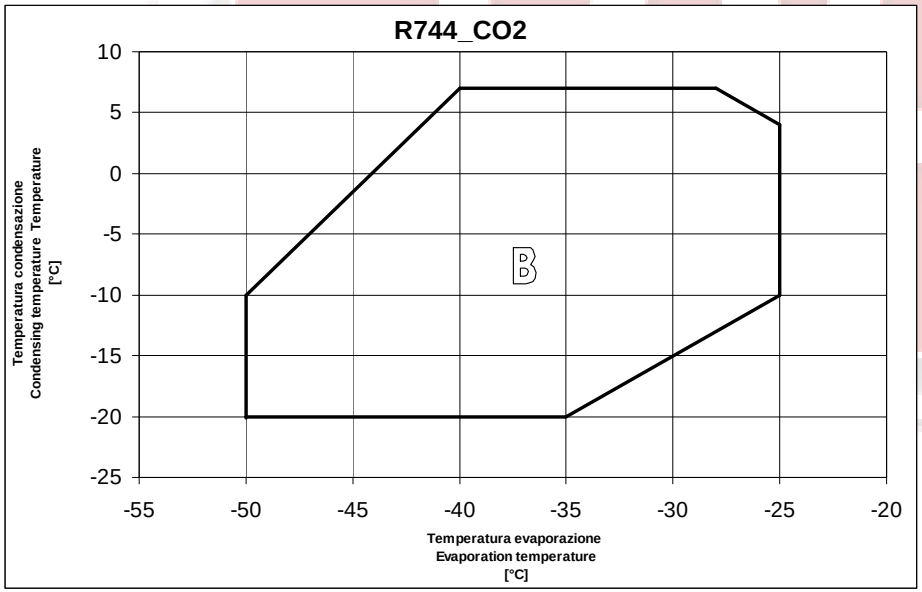


- ➔ **Displacements ranging from 2.9 m³/h to 48.8 m³/h**
- ➔ **Motor power ranging from 1.8 hp to 25 hp**
- ➔ **Capacity ranging from 6.5 kW to 115 kW (-35°C/-10°C)**

3. F-gas REGULATION

➔ Compressor Ranges: SUBCRITICAL MODELS

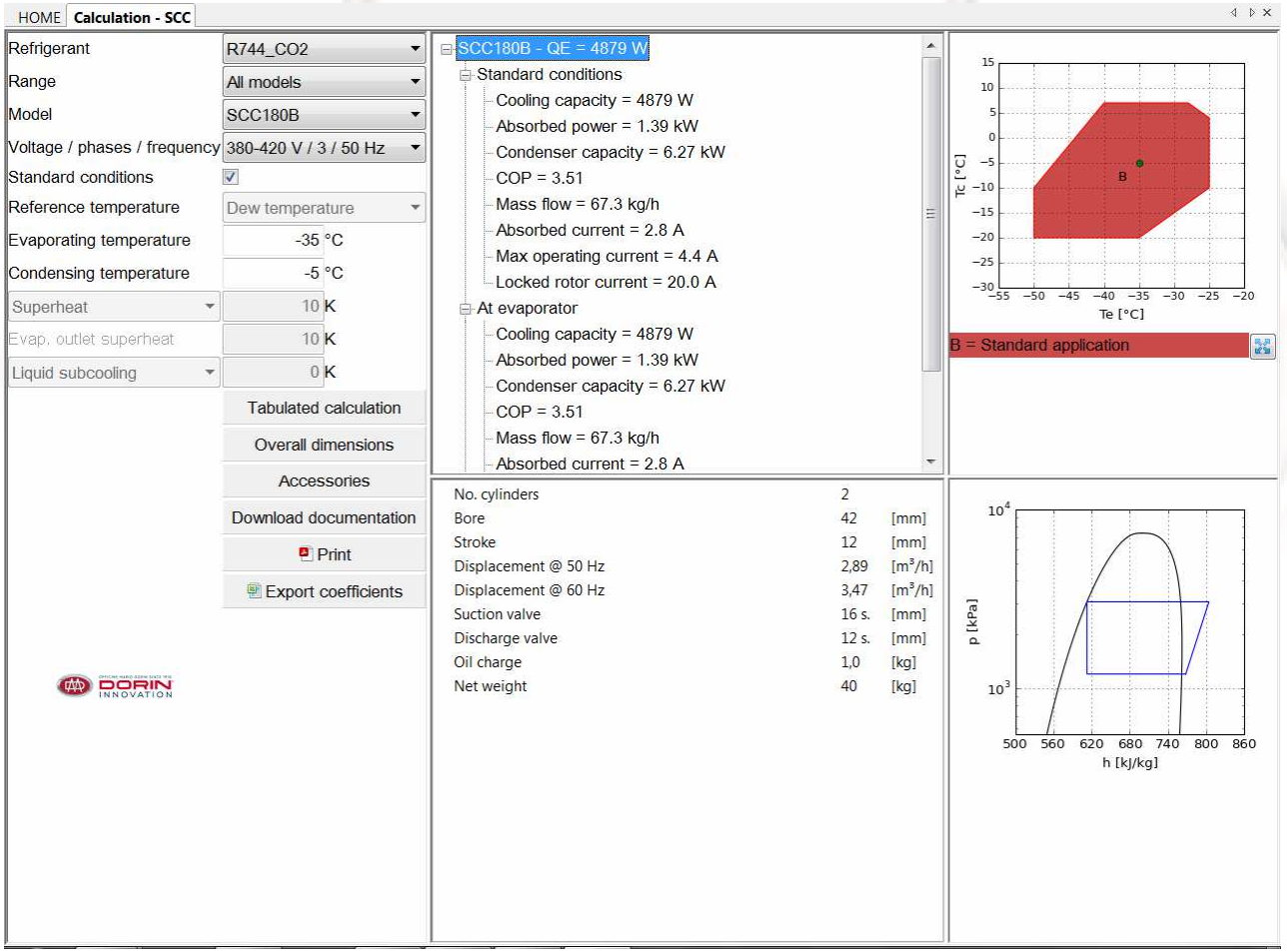
- ➔ Wide application envelope
- ➔ Condensing pressure up to 7°C
  - ➔ Possibility to provide condensation via the AC equipment
- ➔ Pss = 36 bar: prolonged refrigerant containment, safer goods preservation
- ➔ HP and LP safety valves
- ➔ Suction and discharge service valves



3. F-gas REGULATION

➔ Compressor Ranges: SUBCRITICAL MODELS

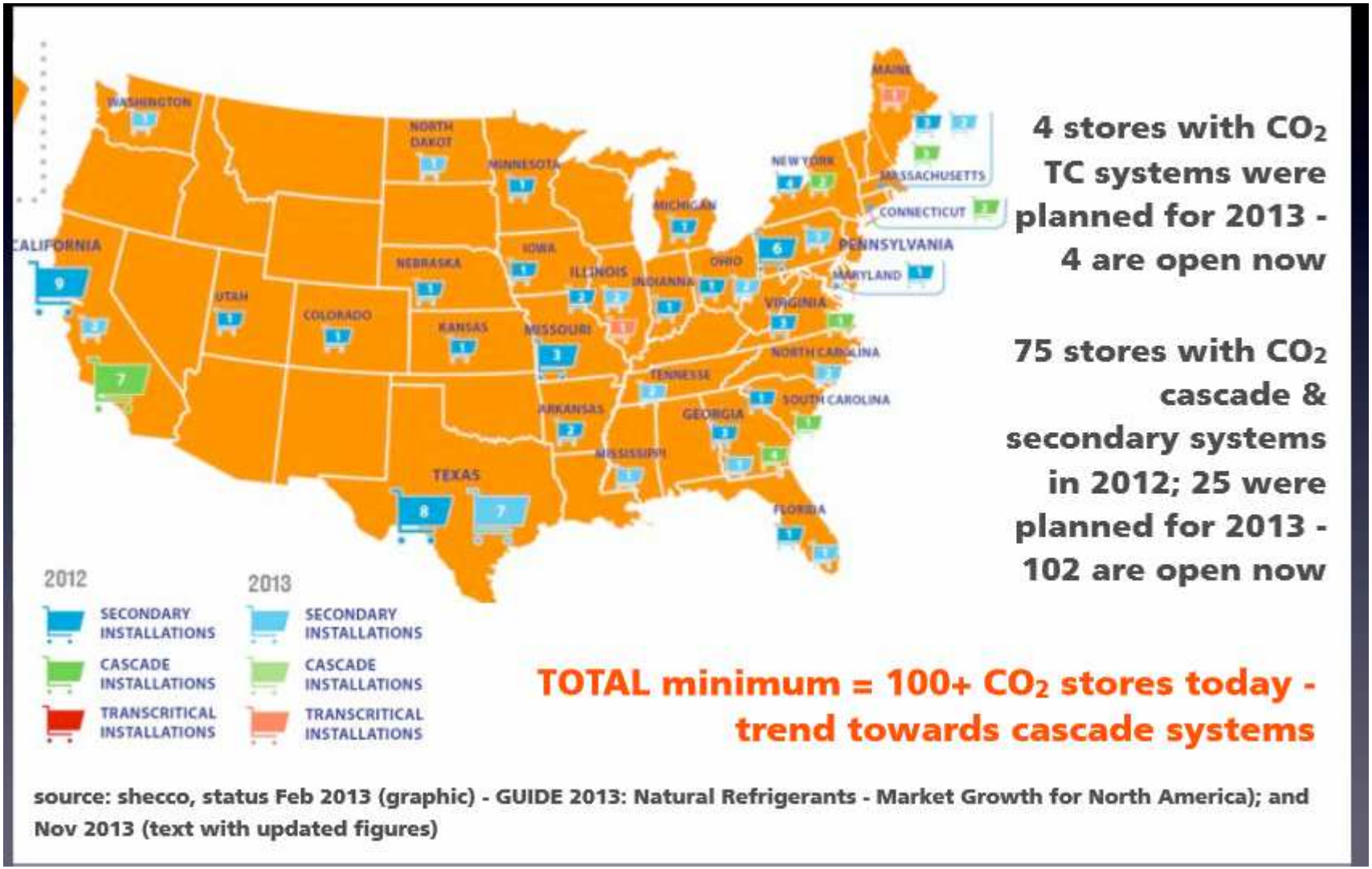
➔ NEW Selection Software available



world: CO_2 transcritical & cascade commercial refrigeration

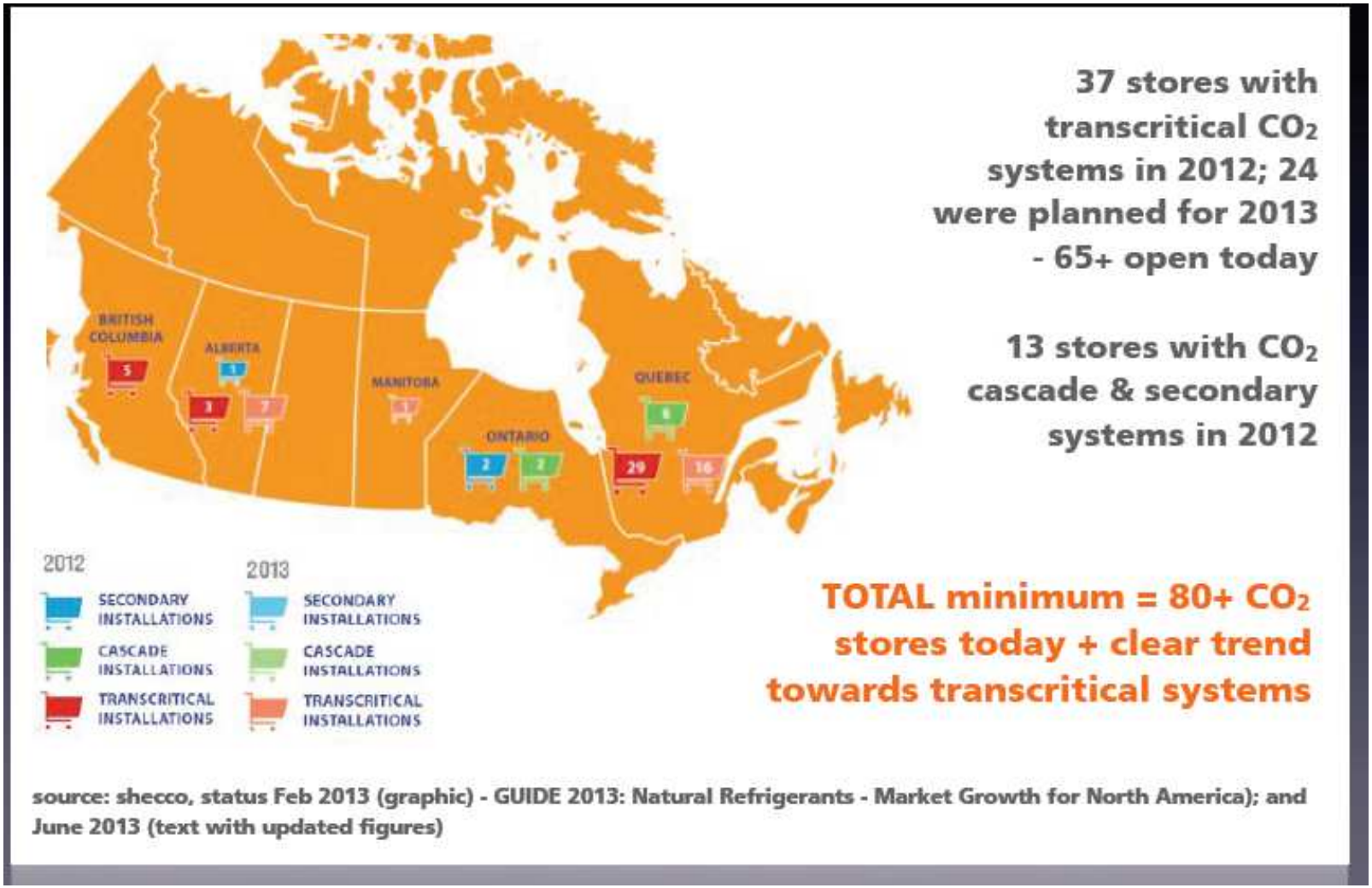
CO2 Supermarkets in USA

font: SCHECCO



CO2 Supermarkets in CANADA

font: SCHECCO



CO2 Supermarkets in JAPAN

font: SCHECCO

approx. 180 stores with transcritical CO_2 systems today;

clear focus on transcritical systems

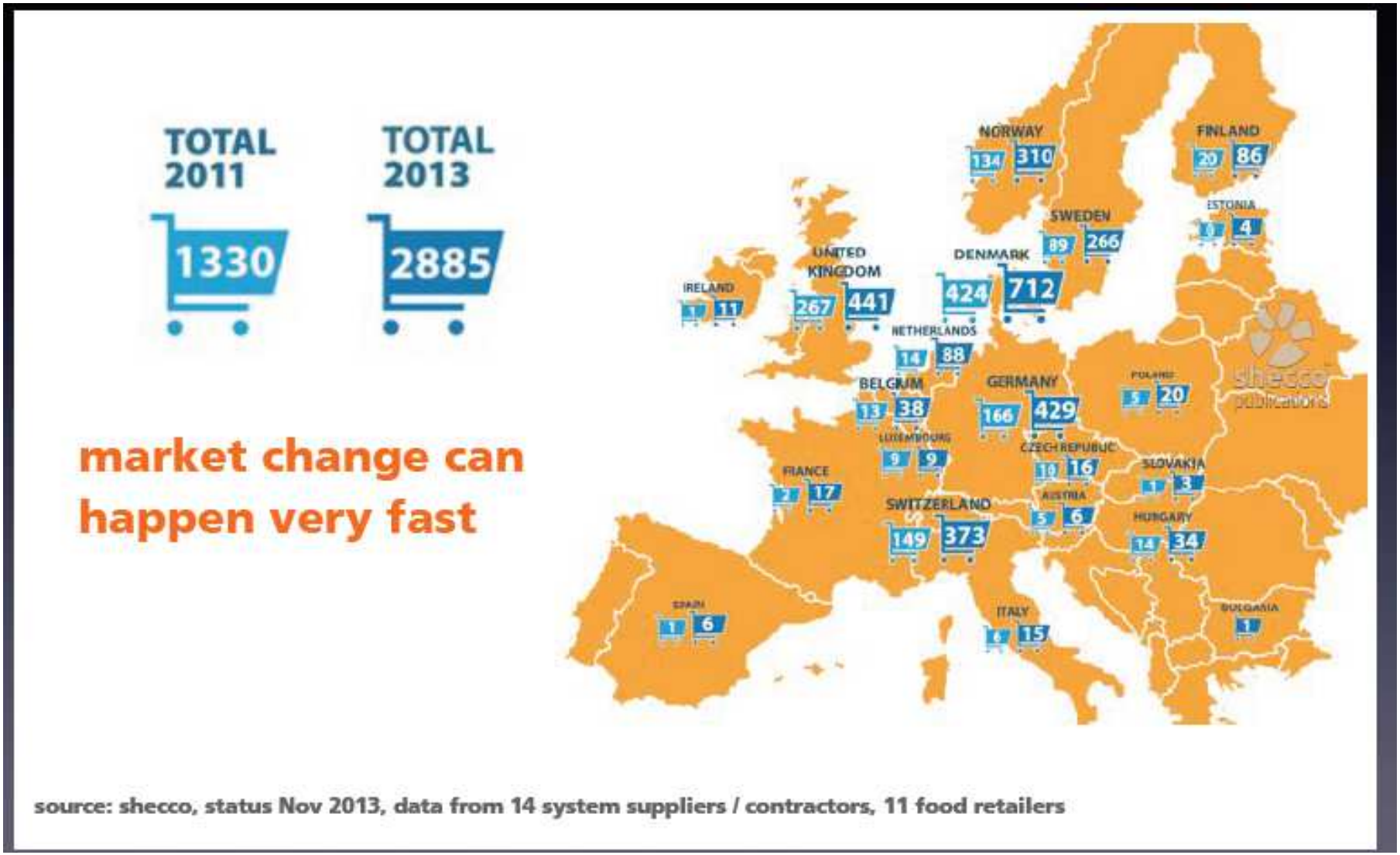
strong focus on convenience stores

market growth expected: NR subsidies, more competition, rising awareness, F-gas law discussion

source: shecco Japan, status Feb 2014

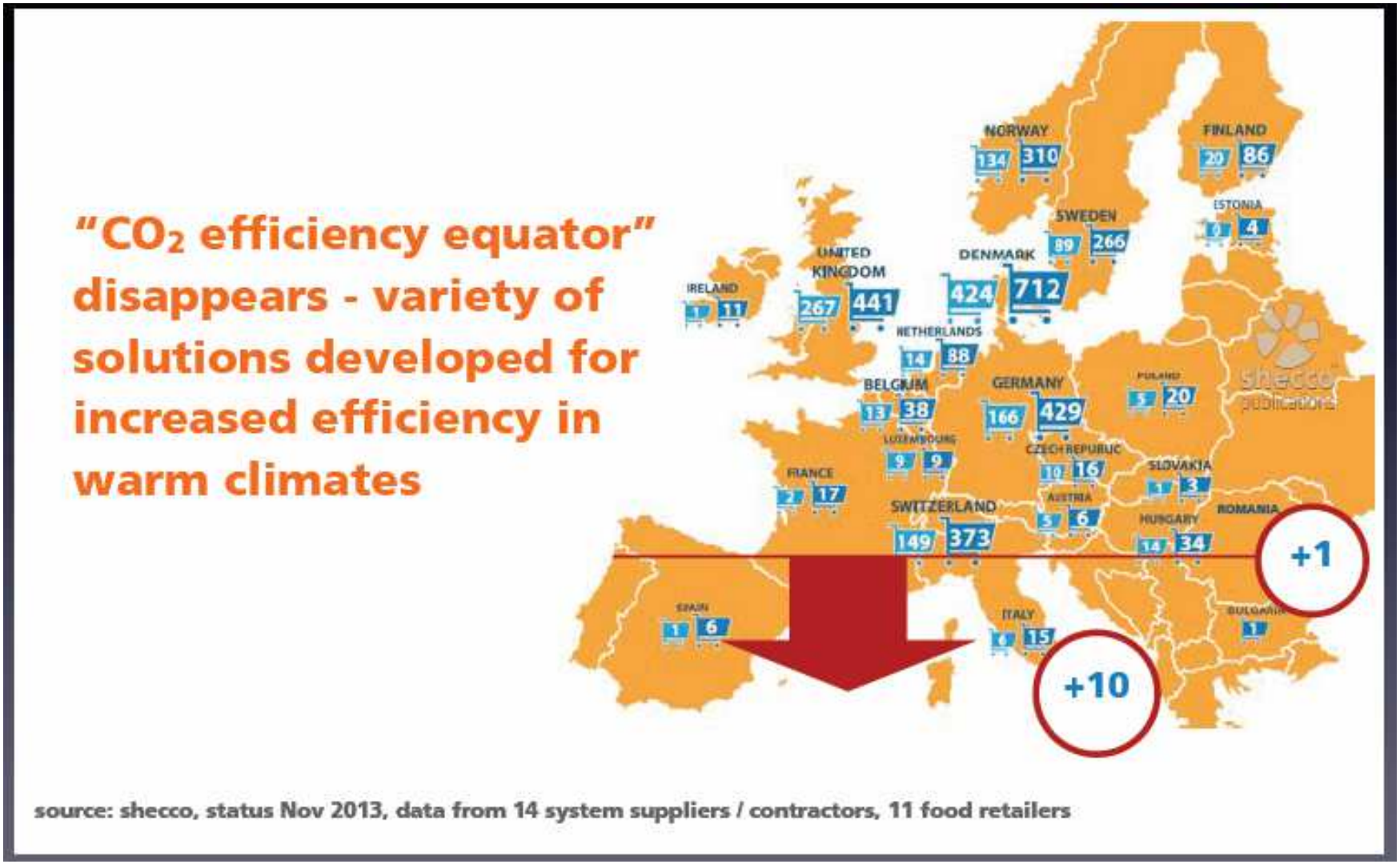
CO2 Supermarkets in EUROPE

font: SCHECCO



CO2 Supermarkets in EUROPE

font: SCHECCO



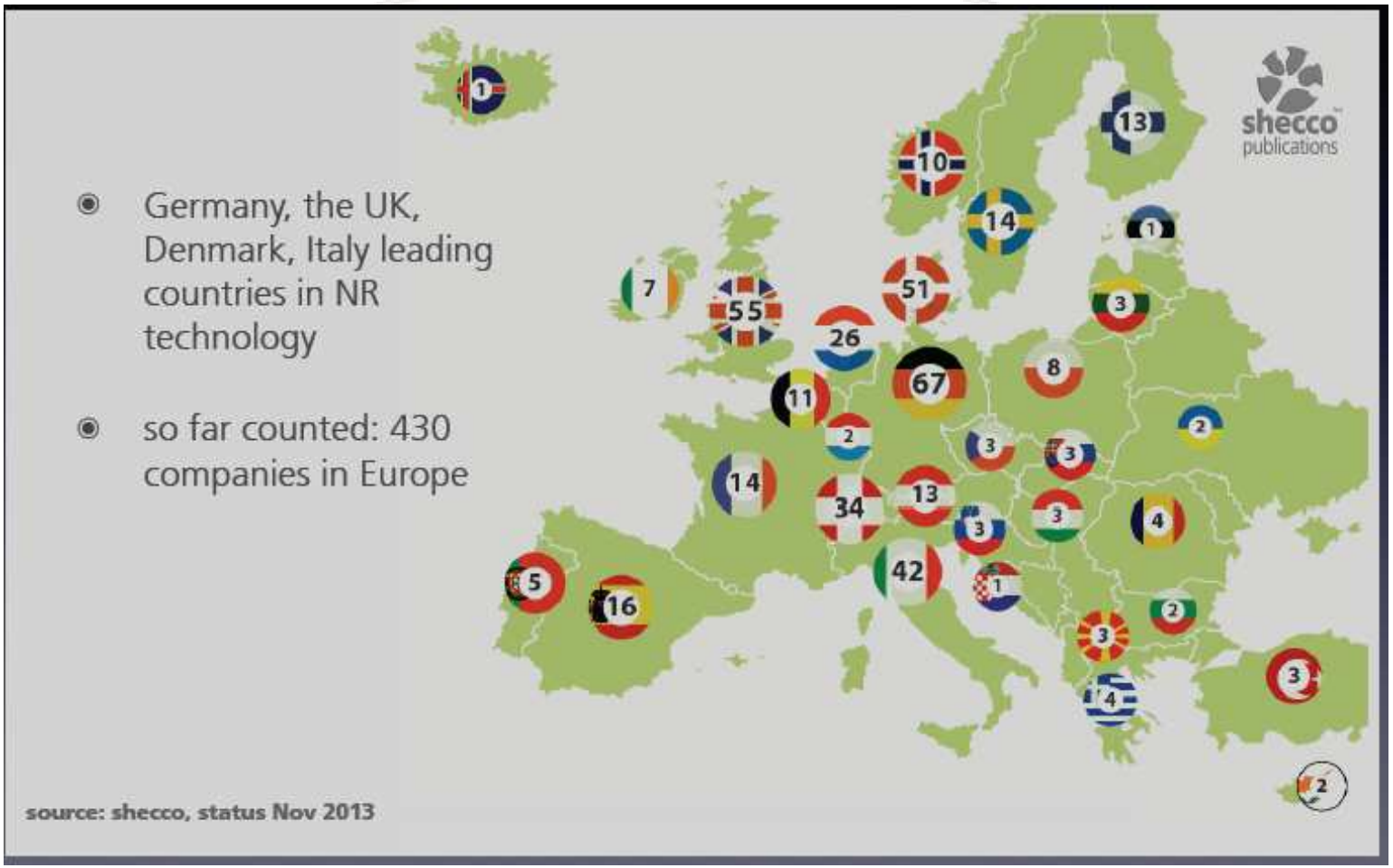
CO2 Supermarkets in EUROPE

font: SCHECCO

CO_2 TC stores: europe 2011-13 (est.)

	2011	2013	Increase in 2 years
Denmark	424	712	+68%
United Kingdom	267	441	+65%
Germany	166	429	+158%
Switzerland	149	373	+146%
Norway	134	310	+131%
EU	1331	2885	+117%

CO2 Manufacturing Companies in Europe font: SCHECCO



➔ Applications - Supermarkets

State of the Art Supermarket Refrigeration

- **Direct Expansion Systems (DX)**
- **Indirect Systems (with Brine Chiller for MT)**

All of them are HFC based plants

Annual leakage rate in Europe is in the range 15-30% of total charge.

Restrictions on the use of synthetic refrigerants are coming into force in several countries

There is a need for a natural refrigerant (no uncertainty for the future) with additional advantages

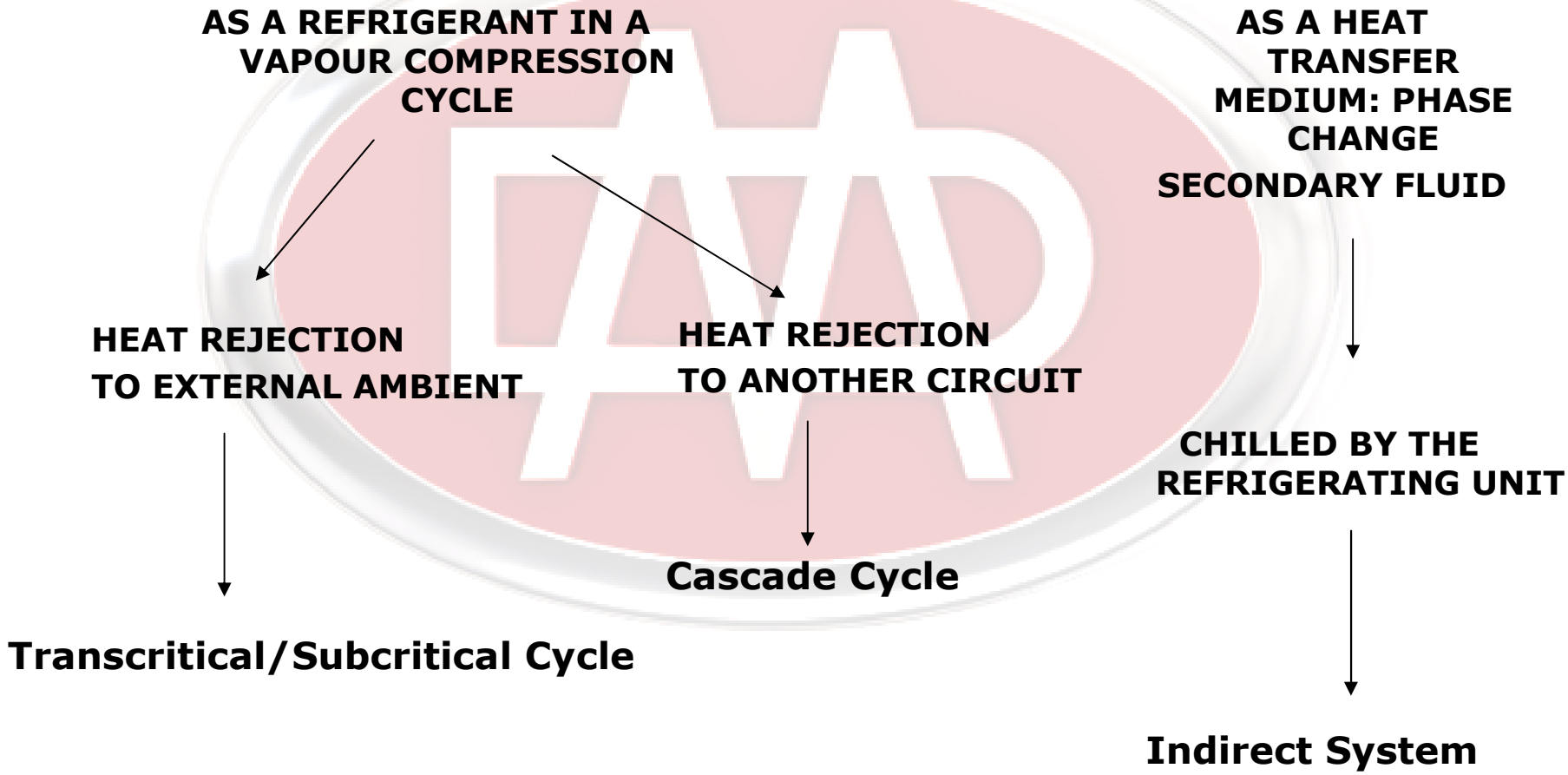
➔ **Applications – Supermarkets**

➔ **CO_2 features**

- **Natural substance existing in atmosphere (350 ppm)**
- **Non toxic**
- **Non flammable (it is one of the by products of combustion)**
- **GWP (Greenhouse effect)=1 (GWP of R404A=3200 ca)**
- **By-product of industrial processes, for refrigeration it can be considered temporarily borrowed before final release to atmosphere (net GWP=0)**
- **Low cost (depending also on purity degree – attention to be paid), about 1/5 to 1/10 of HFC**
- **Available all over the world**

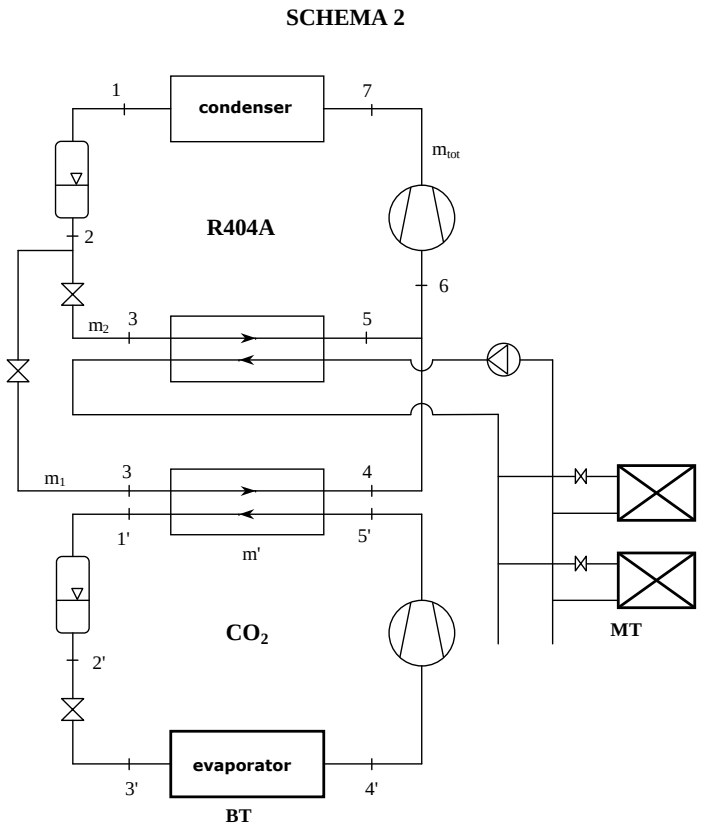
➔ Applications - Supermarkets

How CO_2 is used in Commercial Refrigeration



➔ Applications - Supermarkets

✓ CASCADE SYSTEMS: use of two different refrigerants



➔ CO_2 works only in the LOW PRESSURE SIDE of the installation, in SUBCRITICAL CONDITIONS

➔ max operating pressures for CO_2 circuit around 40 bar_a

➔ standstill must be handled properly

➔ HIGH PRESSURE SIDE normally works with HFCs

➔ need for transfer fluid depending on local legislation

☺ good way to introduce CO2 systems

☹ High first cost, especially with transfer fluid

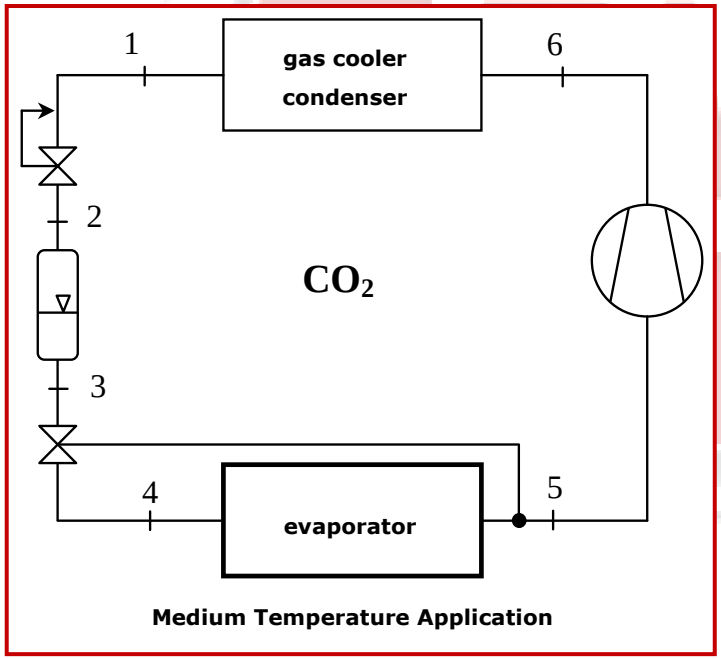
☹ Low efficiency, especially with transfer fluid

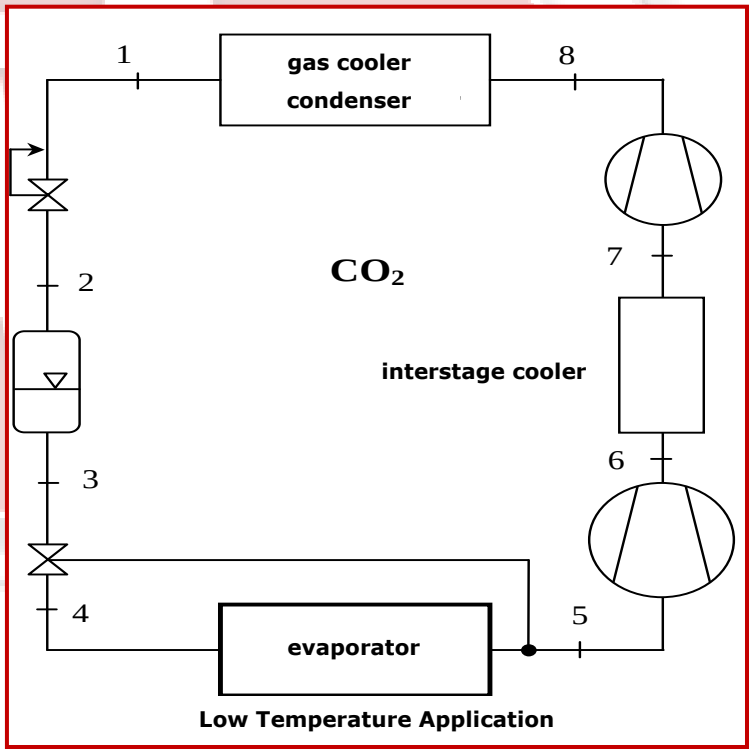
➔ **Applications - Supermarkets**

✓ **DIRECT EXPANSION SYSTEMS: use of CO_2 ONLY**

❑ **no need for a second cooling circuit based on traditional refrigerants**

❑ **perfectly suitable for both very low (-35°C evaporation) and medium low (-10°C evaporation) temperature systems, respectively using double and single stage compressors**





3. F-gas REGULATION

➔ **Applications - Supermarkets**

✓ **DIRECT EXPANSION SYSTEMS: use of CO_2 ONLY**

☹ **To date, high first cost – but comparable with cascade arrangement with transfer fluid**

☹ **Higher pressure involved: max 90 bar for ambient temperature up to 35°C**

☹ **Correct training needed to installers for service purposes, but scenario continuously improving**

☹ **need to handle trans-critical operation**

☺ **High efficiency, especially for moderate climates (Central – Northern Europe)**

☺ **Lower number of components when compared to a cascade systems**

☺ **No need of special arrangements for prolonged standstill (depending on system design)**

☺ **Very smaller pipings, smooth installation**

☺ **Long term alternative to any legislation**

DEVELOPMENT ACTIVITY

Efficiency improvement

Focus on CO_2 refrigeration in Southern Europe climatic conditions

Climatic zones in Europe

1- COLD CLIMATE

2- HIGH PEAK TEMPERATURE
Issue: Capacity at peak conditions

3- HIGH TEMPERATURE FOR LONG PERIODS
Issue: Capacity and & energy consumption

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- **New CO2 System with Auxiliary Compressor**

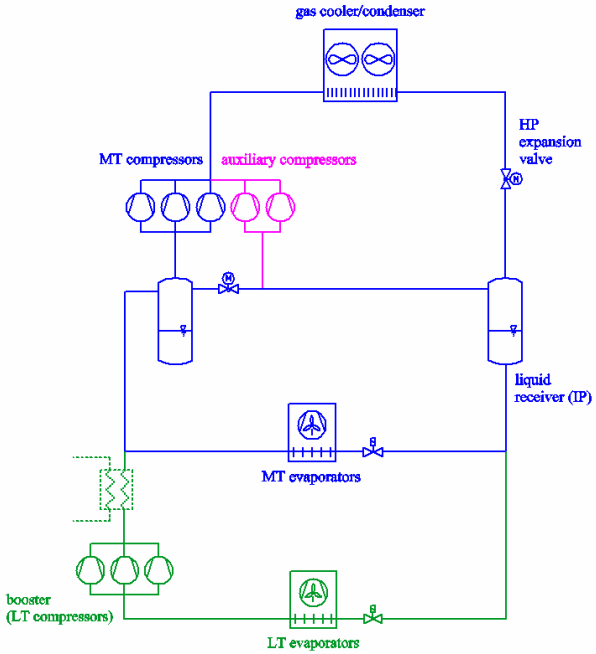

Fig. 1 Schematic of a booster unit with auxiliary compressor

Fig 2. Picture of a booster unit with auxiliary compressor

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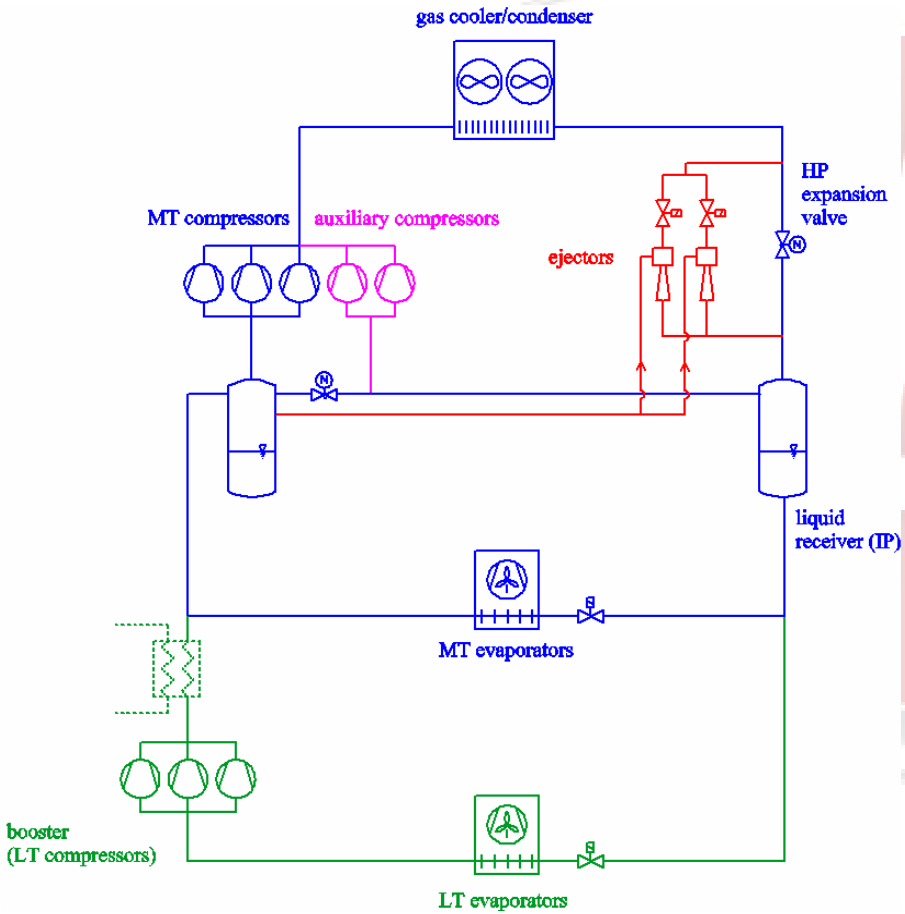
➔Evaporator Overfeeding with Ejector



➔ **Parallel Compression**

Flash Gas re-compressed from a higher level pressure

➔ **EJECTOR:**

Overfeeded Evaporators

Latent Heat used in optimised way

Control of the suction super-heating not necessary

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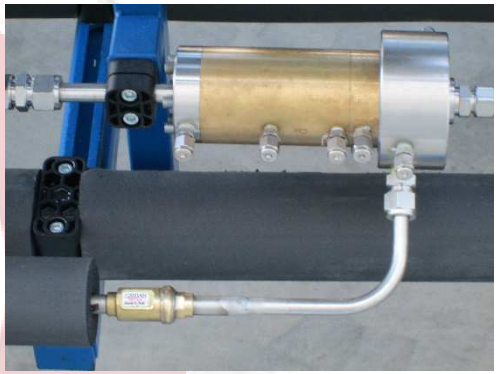
3. F-gas REGULATION

➔Evaporator Overfeeding with Ejector



➔Evaporator Overfeeding with Ejector

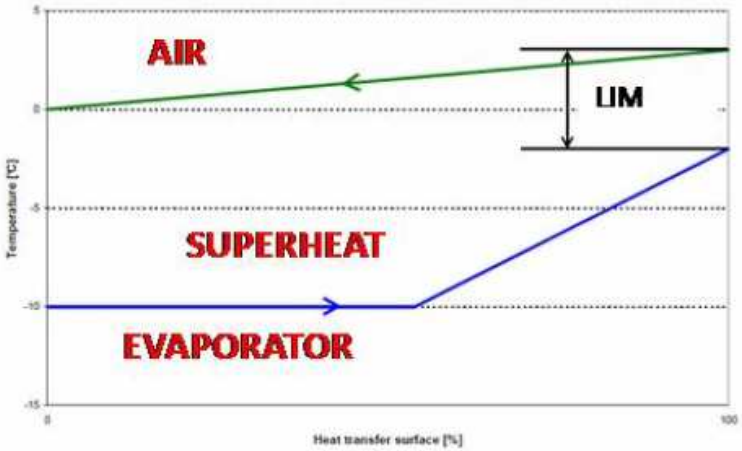


Fig 1. SH control

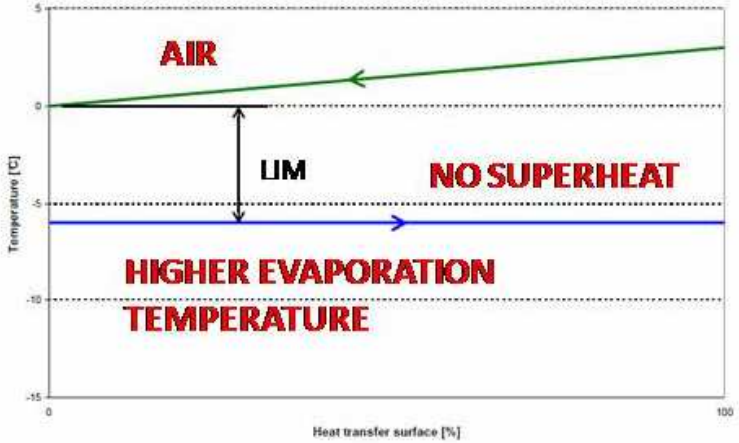


Fig 2. Overfed control

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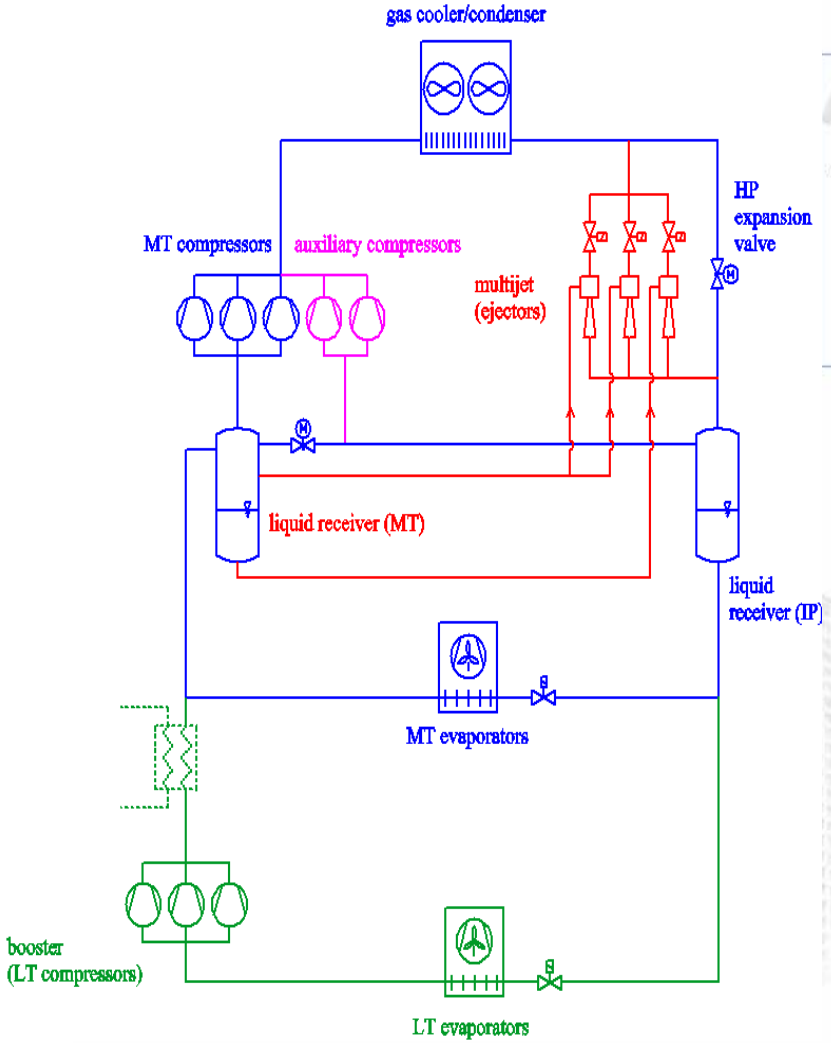
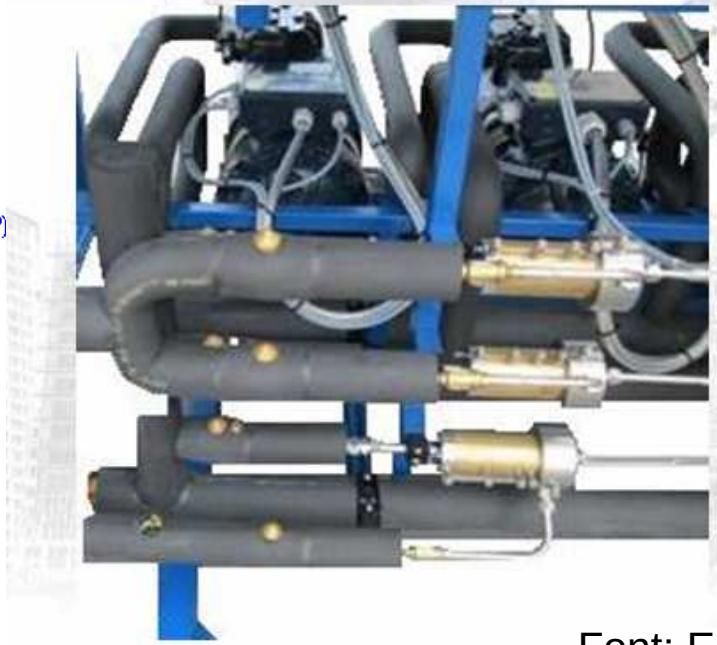
3. F-gas REGULATION

ENERGY RECOVERY FROM EXPANSION PROCESS enjector®



Example
Year : 2013
Type : BOOSTER 4xMT+2xAUX +4xLT
CAPACITY: 150 kW MT / 50 kW LT
n.1 ejector for liquid pumping
n.2 ejectors for energy recovery



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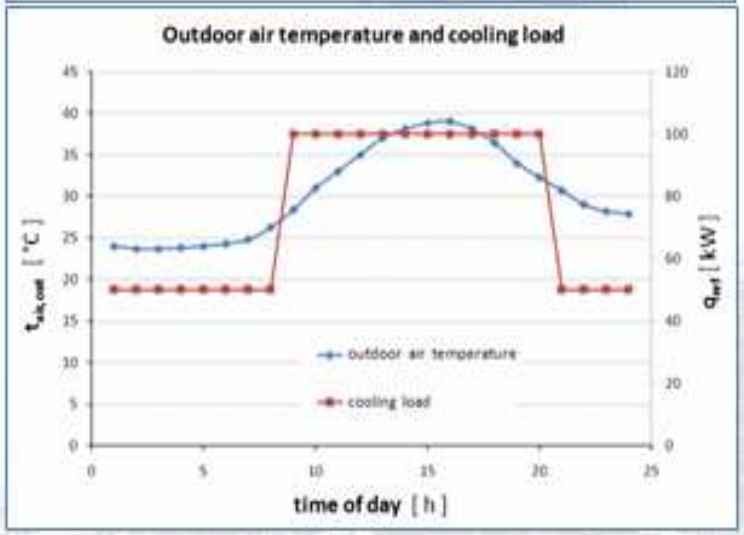
ANALYSIS FOR SOUTHERN ITALY CLIMATE

- Commercial refrigeration system for supermarkets
- Bari (Italy); 41° latitude

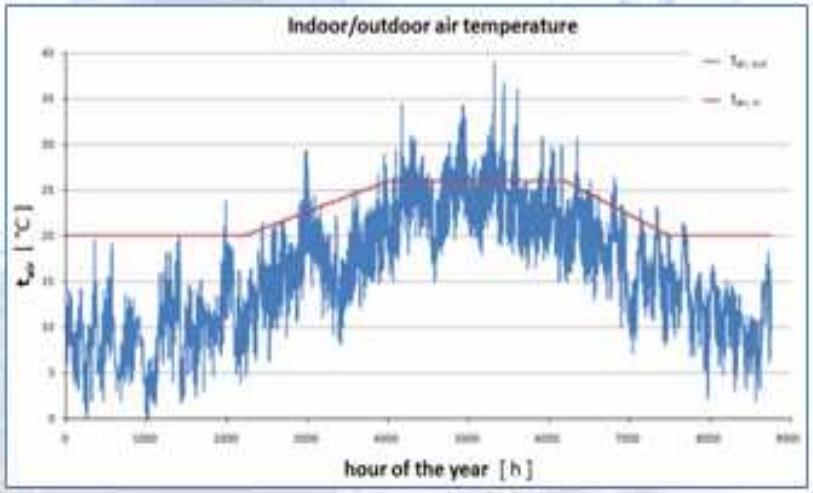
DAY

t_{ext}: 10 August
Test Reference Year (TRY)



YEAR

t_{ext}: "standard year"
Test Reference Year (TRY)



Yearly saving : 20- 25% compared to base «CO_2 standard» cycle

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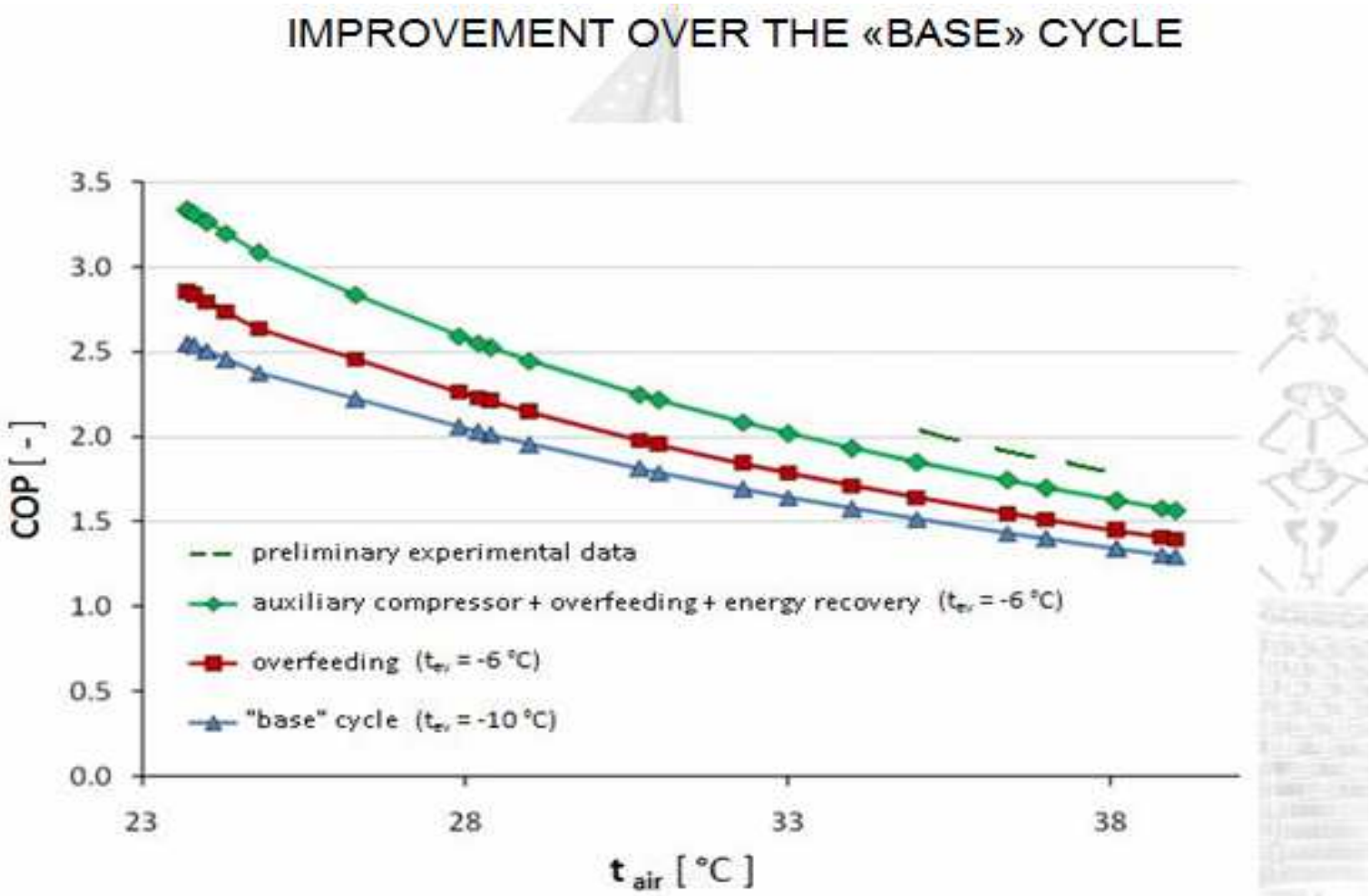
3. F-gas REGULATION



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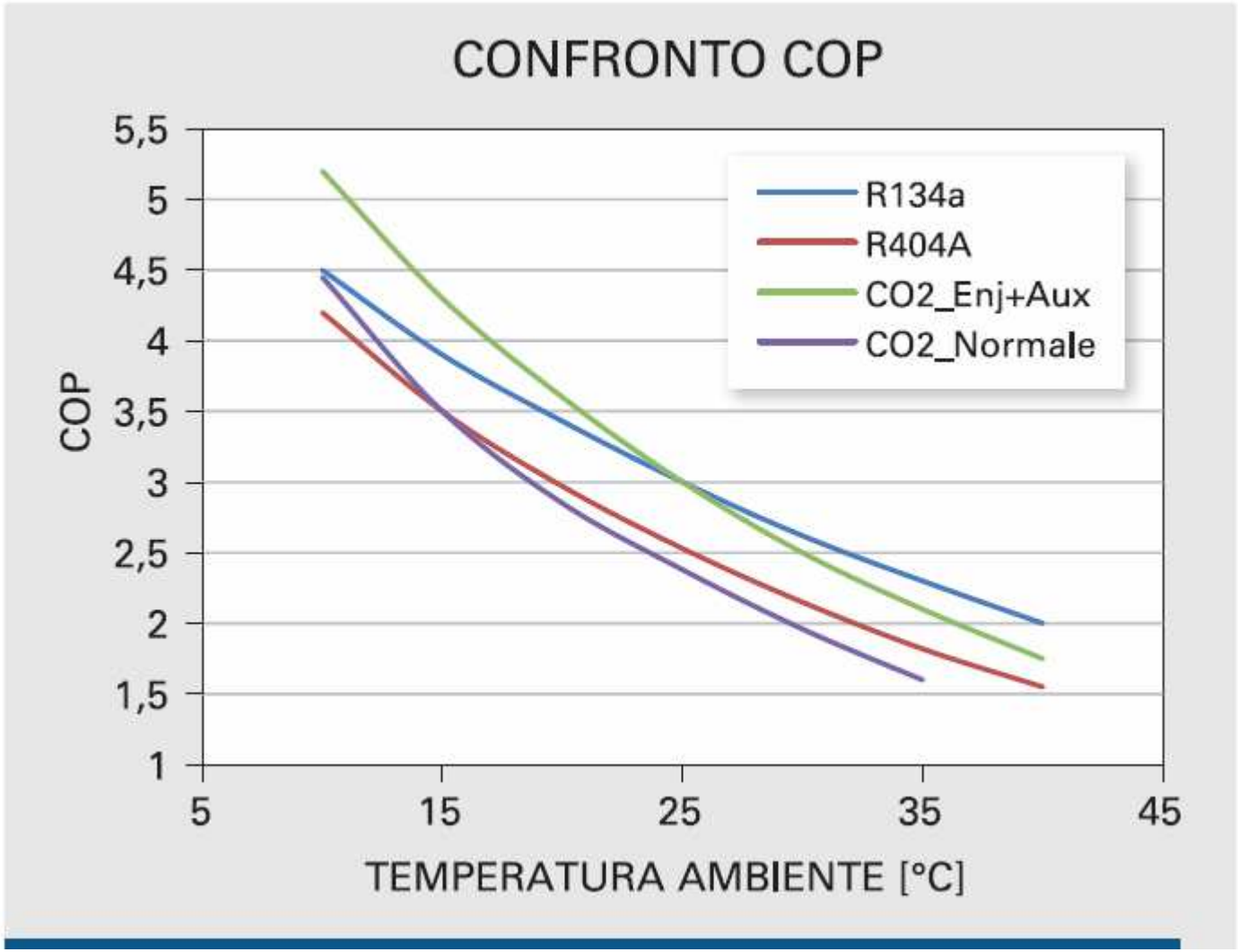
3. F-gas REGULATION



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3. F-gas REGULATION

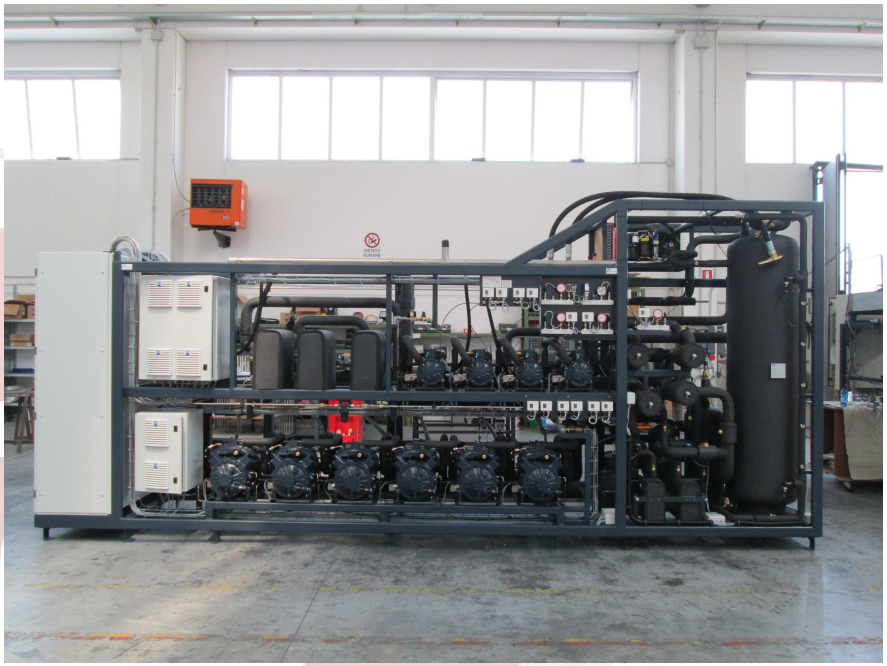
KIND COURTESY of TESCO

3. F-gas REGULATION

PROFROID / GREEN & COOL – FRANCE / SWEDEN

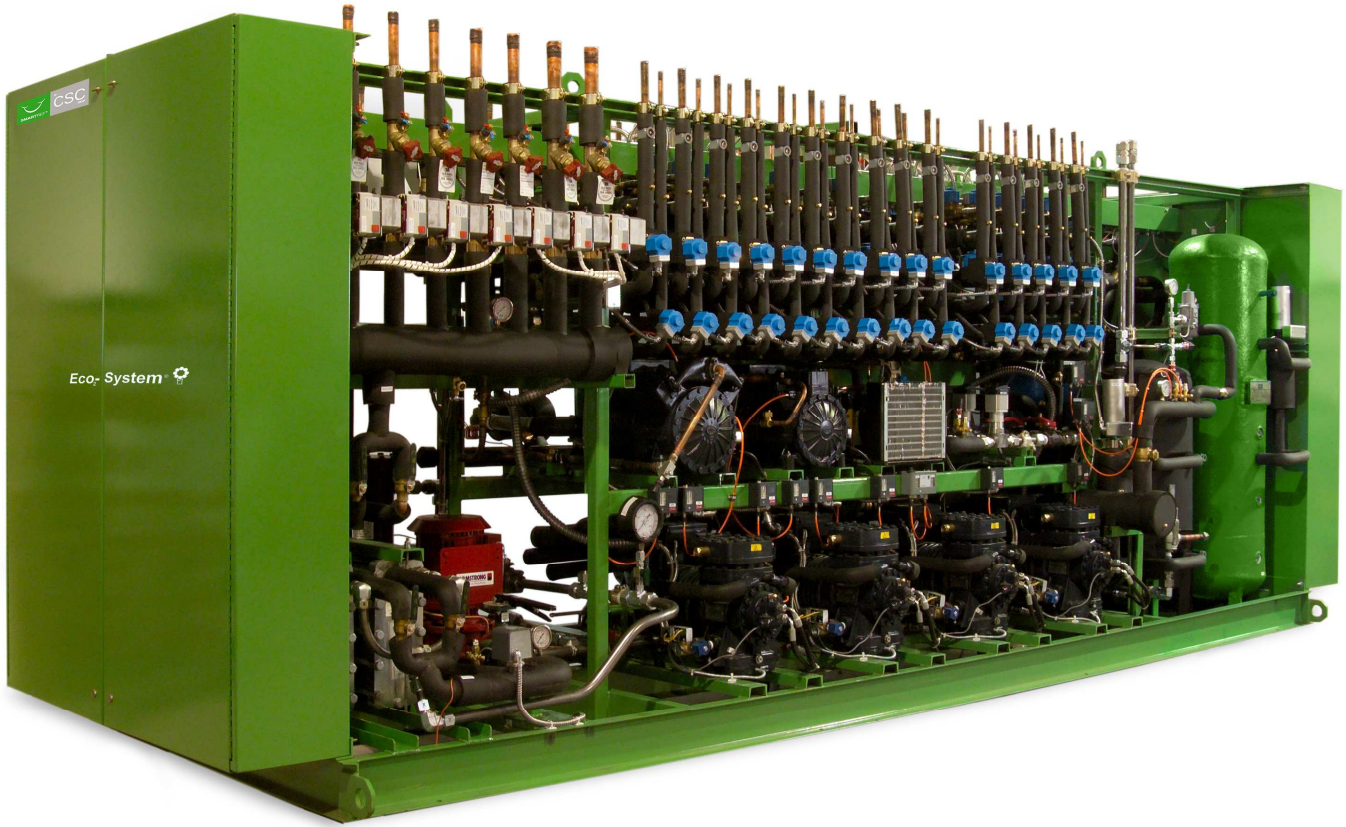
Massimo Casini **China Refrigeration 2014** Beijing April 10°, 2014

3. F-gas REGULATION



ENEX - ITALY

3. F-gas REGULATION



SMARTREF – CANADA

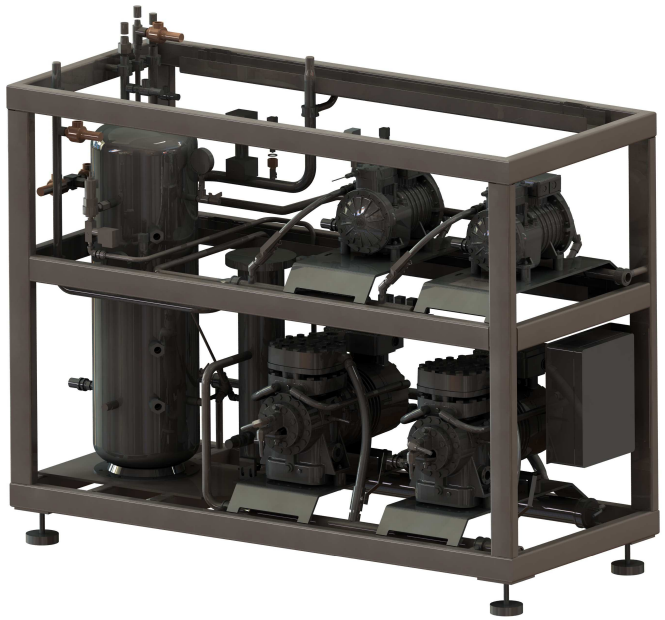
RETAIL REFRIGERATION (HOT GAS DEFROST)

ICE-SKATE ARENA

3. F-gas REGULATION

COSTAN - ITALY

3. F-gas REGULATION



ADVANSOR by HILL PHOENIX - DENMARK

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LENNOX / HEATCRAFT – FRANCE

RETAIL REFRIGERATION

BAHÇELİEVLER CARREFOUR

CO2 COMPRESSOR PACK

COZUM, TEKSO, EPTA – TURKEY

3. F-gas REGULATION

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NEWS >> INDUSTRY NEWS

Exclusive interview: Beijing's first CO_2 refrigeration store energy savings

27 February 2012

2 comments | rate: ★★★★★ Votes:3 Login or Register to vote

On 23 February 2012, retailer Tesco opened its second CO_2 cascade refrigeration sto the capital city of Beijing. The R744 system is expected to save 35% of energy. considering the use of CO_2 refrigeration in one of its stores in China. Fute Refrigeratio Ltd installed and commissioned both CO_2 refrigeration systems for Tesco. Mr. Zha provided R744.com with exclusive insights.

R744.com: Compared with FUTE's first CO_2 refrigeration system for Tesco's supermarket in Shanghai, what is the difference and improvement of the Beijing store?

Mr. Zhang MengLong: The Beijing store is around 10% larger than the first store in Shanghai. The big difference with the Beijing store is the level of outside expertise required. The rack for the Shanghai store was manufactured in Australia and there was support with the design, installation & commissioning from our Australian partners. However, the Beijing store's CO_2 rack was built entirely by Fute Refrigeration here in China, which also did the design, installation as well as the comm

The main difference from a design point was the use of Dorin CO_2 compressors and the Presscon control system which controls all the CO_2 and high stage racks, all VSD devices, as well as MT display cabinets and cold/preparation rooms. The Presscon system also provides remote monitoring and controlling. In addition, we installed CO_2 ice makers by Maja. We also installed VSD to drive the water pump (water cool condenser).

Timothy Held | *4 hours ago*
Posted new comment: Two options include REFPROP

FUTE REFRIGERATION – TESCO CHINA

OFFICINE MARIO DORIN SINCE 1918 DORIN INNOVATION

case: CO_2 heat pumps in China

shecco
SUSTAINING OUR ATMOSPHERE

- **Bumade station on the Qinghai-Tibet railway line**: three 50kW heat pumps are operating at 4,800m above the sea level for space and water heating - they work well even during winter at outside temperatures of -30°C = the highest in elevation and the lowest in operating temperature in the whole of China
- **Wuhan University:** 50% energy saving with CO_2 heat pump combined with an electric boiler for hot drinking water production since October 2011 (as compared to a 100% electric boiler) - 5 tons hot drinking water per day
- overall: 50-70 CO_2 heat pump projects in China and production capacity of 100,000 units / year

CO_2 HEAT PUMPS ARE GROWING IN POPULARITY IN CHINA

China

The CO_2 heat pump market is developing fast in China, with the technology being applied in hospitals, train stations, schools and public buildings.

Heating Bumade Station on the Qinghai-Tibet railway line, at 4,800m above sea level: Three 50kW CO_2 heat pumps were installed in a 3000 m² maintenance area of the Bumade railway station to provide space and water heating. According to supplier Meilinda, the heat pumps work well even during winter when the outside temperature is as low as -30°C. The heat pump project is the highest in elevation and lowest in operating temperature in China.

50% energy saving for hot drinking water production in Wuhan University: A CO_2 heat pump water heater was installed in October 2011 in the Wuhan University of China to provide hot drinking water. The combined CO_2 heat pump and electric boiler saves 50% in energy for the university compared with a 100% electric boiler. The system is able to provide 5 tons hot drinking water per day to students.

Increasingly more CO_2 heat pumps are used in space and water heating in China. A group of domestic manufacturers have emerged. Today there are more than 30 CO_2 heat pump installations across the country.

3. F-gas REGULATION

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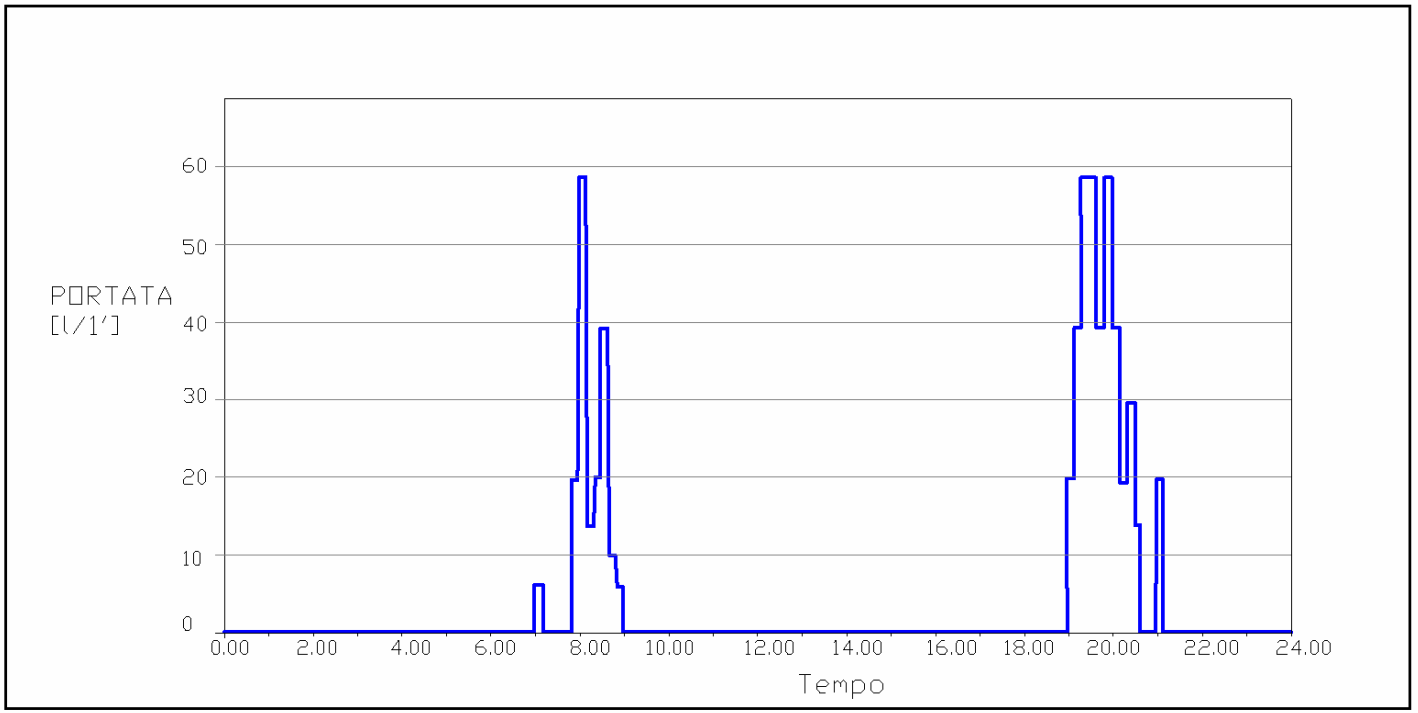
Heat Pumps Systems – Typical Topics

- Traditional Heat Pump with tank and 3-way valve
- Direct tank and tank with heat exchanger
- Legionella disease
- Heat pump based on transcritical cycle with stratification tanks allows higher water temperature, maintaining a good efficiency level

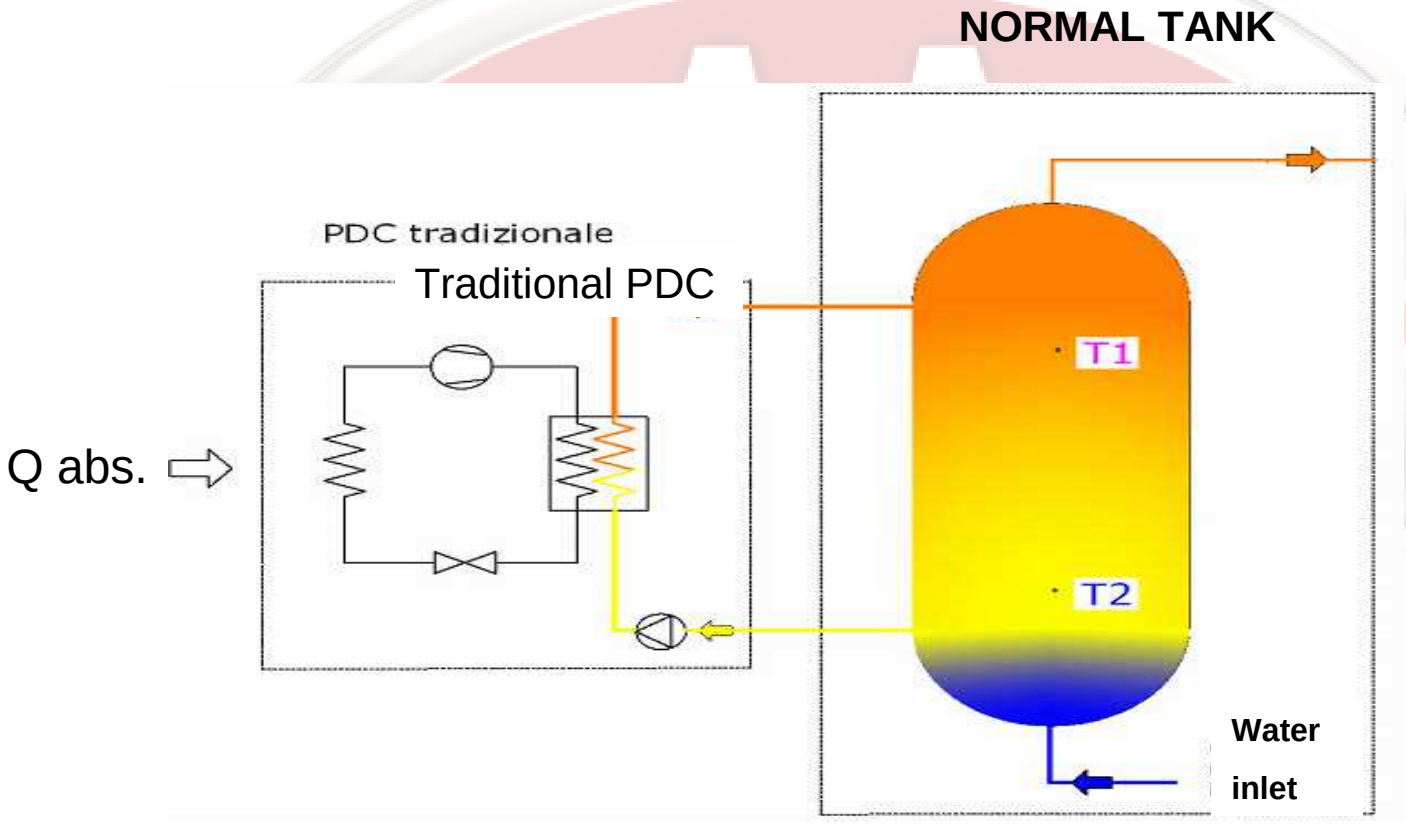
Heat Pump (Water/Water) for Sanitary Hot Water Purpouse

Application: Residential Complex (Requested production: 5800 Lt/day @ 45°C)

Typical Hot Water Demand Profile

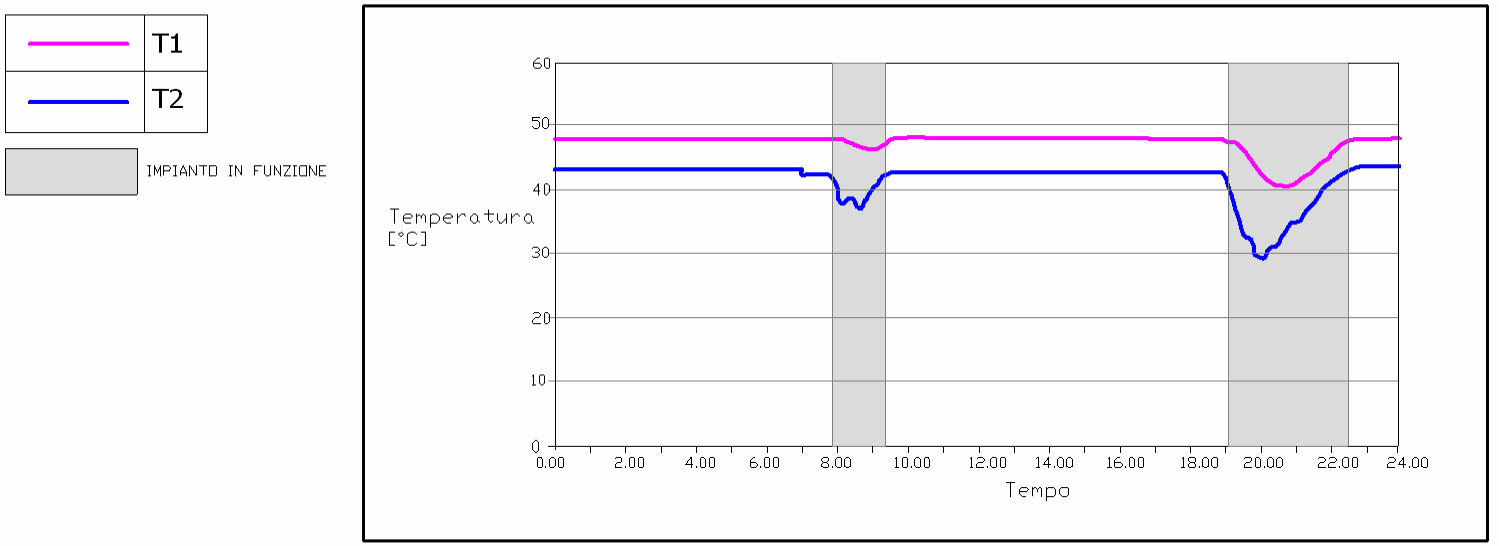


NORMAL BATCH PROCESS:



NORMAL BATCH PROCESS:

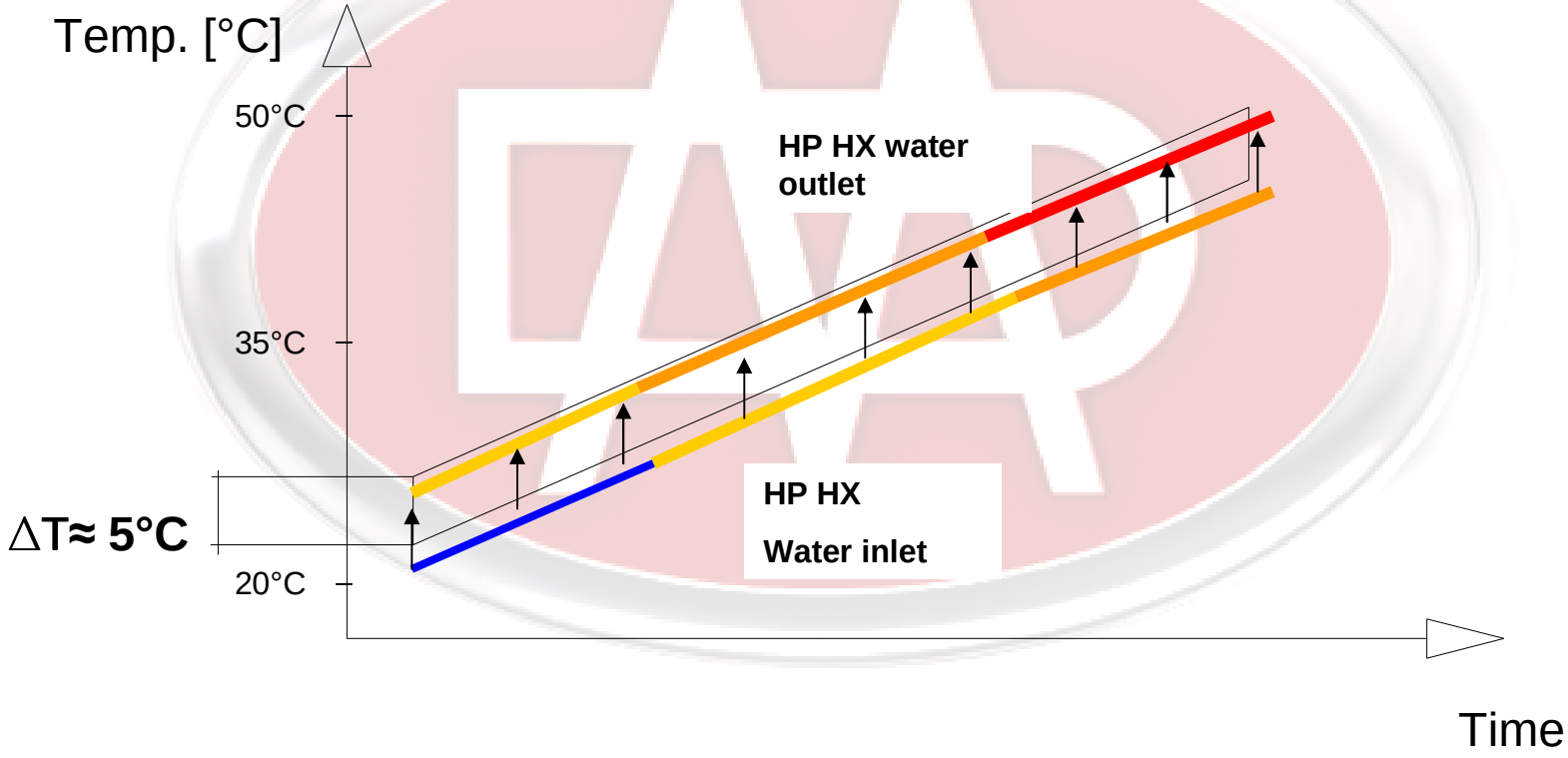
Standard Design: Traditional Heat pump with mixed/stratification tank



Tank capacity: 8000 Liters
Operating time: 5 hours/day
Thermal Power: 50Kw
Electrical Power: 15.6 kW
Electrical Consumption: 75 kWh/day

NORMAL BATCH PROCESS:

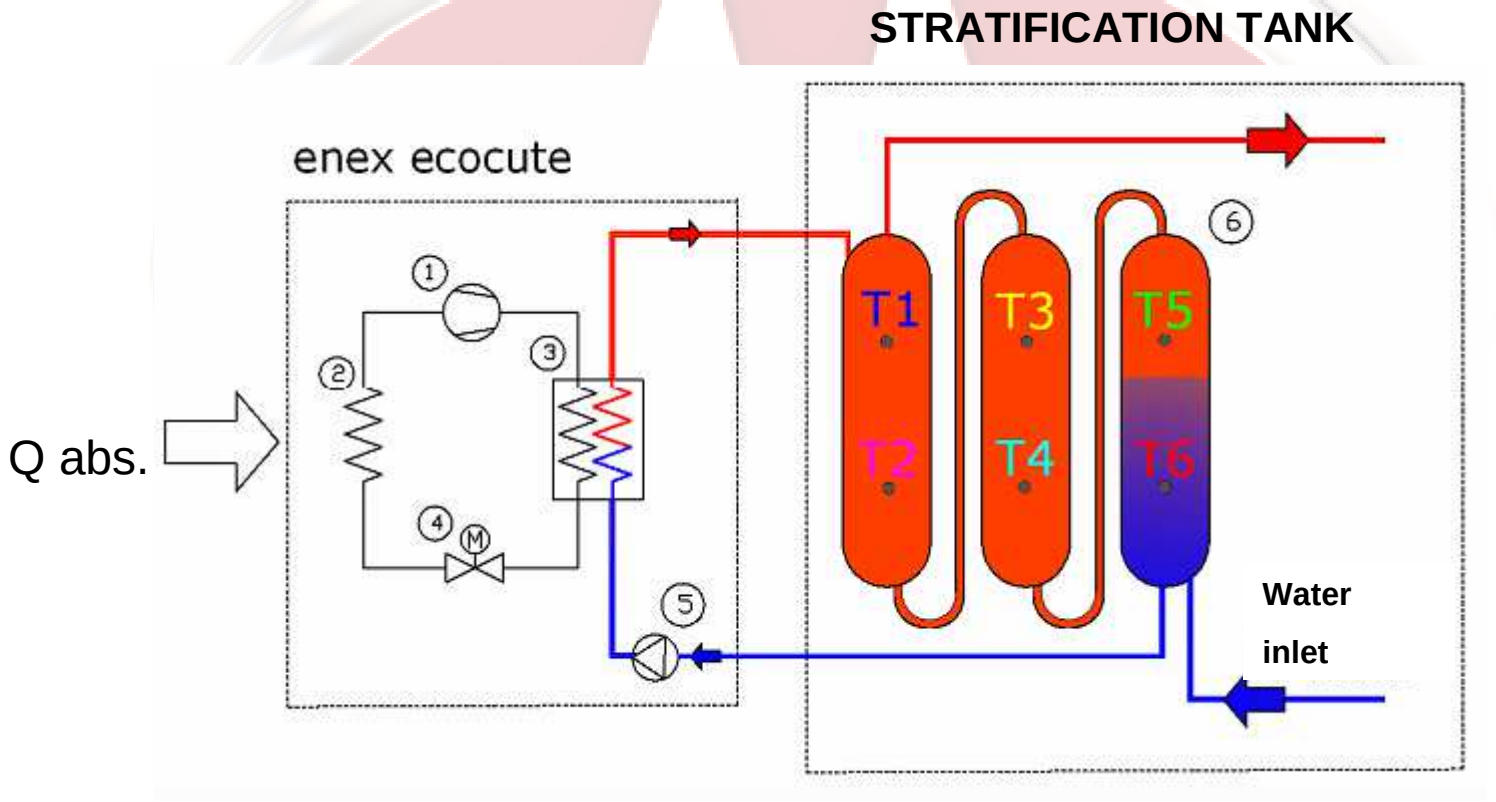
WATER TEMPERATURE



CO_2 Heat Pumps- EcoCute Design

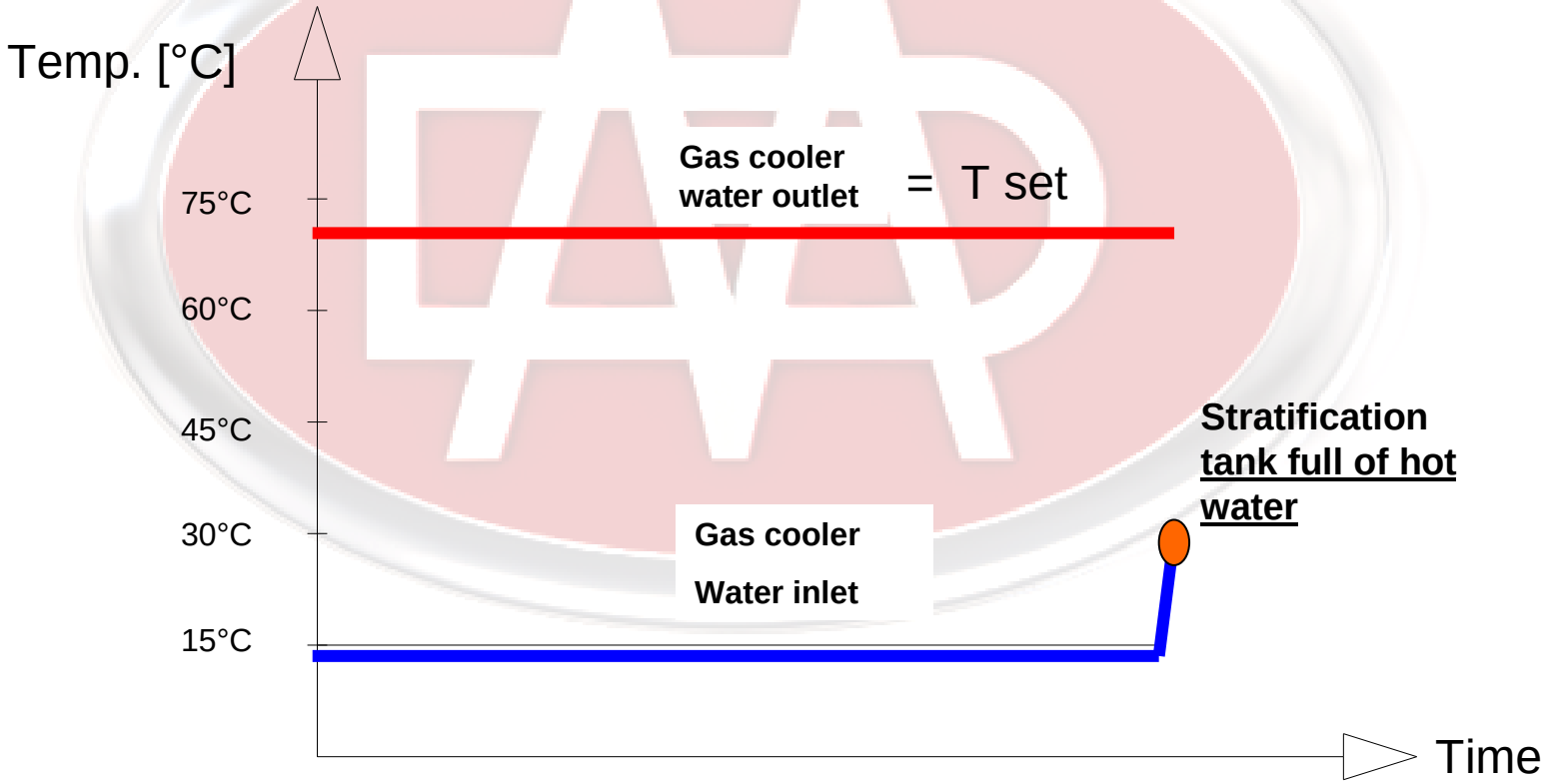
- LPR system
- LP side design pressure: 80 bar
- The internal heat exchanger is necessary (LPR / to increase discharge temperature)
- Stratification water tank (best achieved by connecting tanks in series)
- Operating logic charge-discharge (nigh time operation), specially for use of hot water in limited periods (i.e. Hotels)
- The following slides are referred to a Heat Pump with a Double Wall Plate Heat Exchanger Gas Cooler, but there are available other versions with tube-in-tube type too.
- The graphics are based on experimental results but are showed just as an example.

CO_2 DIRECT PROCESS :



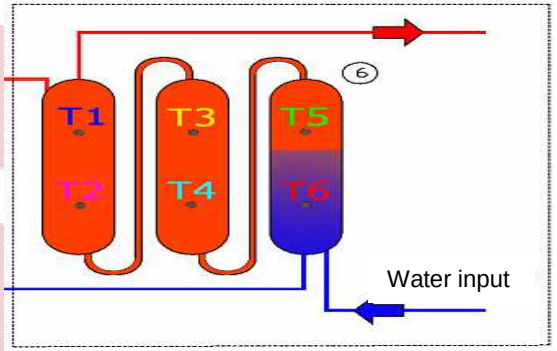
CO_2 DIRECT PROCESS :

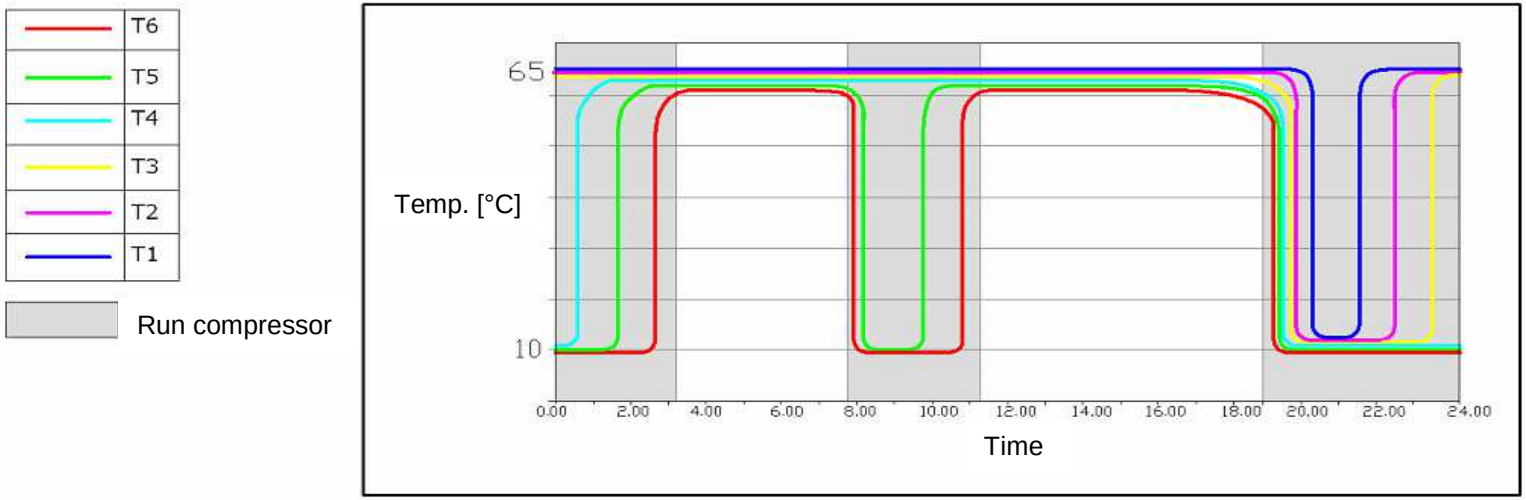
WATER TEMPERATURE



CO_2 DIRECT PROCESS :

STRATIFICATION TANK METHOD





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EXPERIMENTAL RESULTS : HEAT PUMP PERFORMANCE (B)

Set point	[°C]	**60**	**70**	**80**	**60**	**70**
Gas cooler water inlet temperature	[°C]	14.7	14.5	14.5	20.3	20.1
Water delivery temperature	[°C]	60.2	69.8	80.0	59.6	69.3
Gas cooler water mass flow rate	[kgh^{-1}]	416.9	313.7	264.6	457.0	356.1
Gas cooler pressure	[bar]	96.7	98.2	109.8	91.0	104.1
Gas cooler outlet temperature	[°C]	22.4	33.5	34.5	34.5	33.0
Evaporator water inlet temperature	[°C]	15.1	15.4	15.5	22.2	21.4
Evaporation temperature	[°C]	1.8	3.9	4.2	8.3	8.7
Gas cooler power	[kW]	20.6	18.6	18.9	19.5	21.5
COP	[-]	3.8	3.4	3.1	3.9	3.7

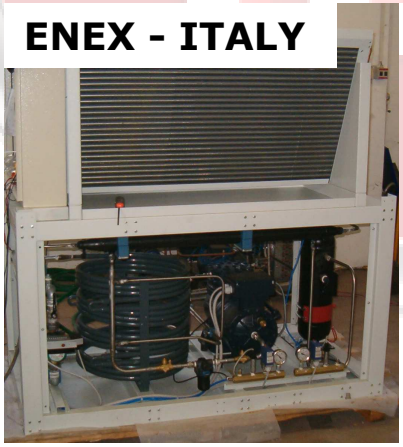
CONCLUSIONS

- The concept of CO2 Heat Pumps with Stratification water tank is the best one since that it permit to have continuosly hot water at controlled temperature.
- This presentation shows an example of CO2 Heat pump that is produced already in large scale and that it is reaching very positive results in term of reliability and running costs.
- The presented data confirm that the performances of CO2 heat Pumps are very high-levels ones and they permit significant energy saving and more environmental friendly solution.

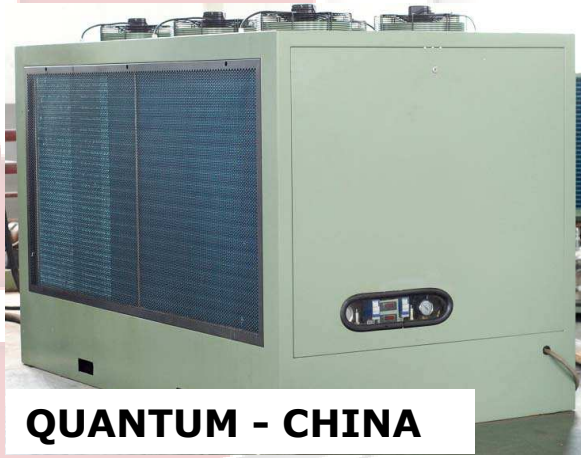
REFERENCES

➔ HEAT PUMPS

ITOMIC – JAPAN



ENEX - ITALY



QUANTUM - CHINA

QUESTIONS ?