



OFFICINE MARIO DORIN SINCE 1918
DORIN[®]
INNOVATION





1. INTRODUCTION
2. CO₂ SYSTEMS: HOW TO IMPROVE ENERGY EFFICIENCY
3. HYPERMARKET CARREFOUR IN ITALY
4. CONCLUSIONS
5. ENERGY SAVING: 2-STAGE vs SCREW COMPRESSOR IN LT APPLICATIONS

• 1. INTRODUCTION



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*Can we phase-out the use of F-gases
in commercial refrigeration systems?*



- ✓ F-gas REGULATION IN EUROPE IS THE MAIN DRIVER TOWARD LOW GWP REFRIGERANTS
- ✓ CALIFORNIA AND OTHER 24 STATES IN USA ARE INTRODUCING STRONG RESTRICTIONS FOR REFRIGERANT WITH GWP>150
- ✓ NEW HFO SOLUTIONS ARE ALREADY UNDER INVESTIGATION FOR POLLUTING THE ENVIRONMENT WITH ACID RAINS (...ANOTHER PHASE-OUT IN FEW YEARS?)
- ✓ CO₂ LOOKS LIKE BEING ONE OF THE MOST VIABLE SOLUTION

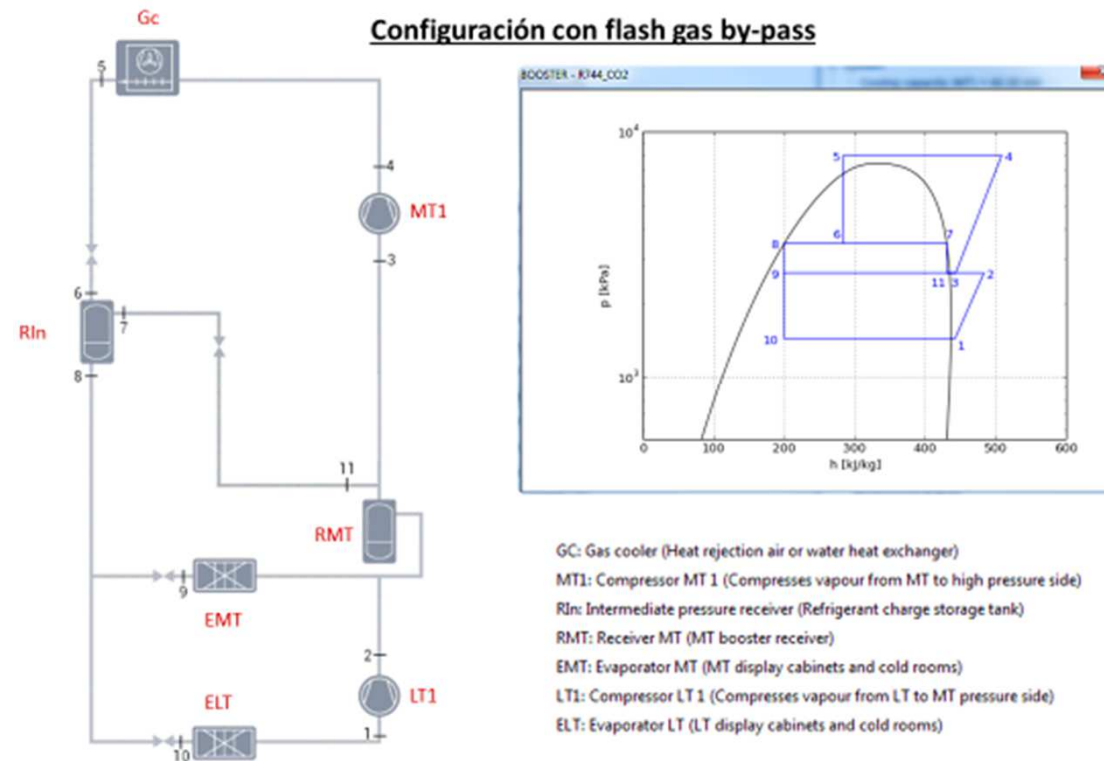
2. CO₂ SYSTEMS: HOW TO IMPROVE ENERGY EFFICIENCY



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- CO₂ SYSTEMS HAS BECOME A VERY POPULAR APPLICATION IN COLD CLIMATES
- STILL DOUBTS PERSIST ABOUT THE EFFICIENCY CO₂ IN WARM CLIMATES



IF YOU COMPARE A A SIMPLE BOOSTER SYSTEM WITH FLASH GAS BYPASS (FGB) WITH TRADITIONAL HFC SYSTEMS OR WITH CASCADE SYSTEMS HFC-CO₂ THIS IS PROBABLY TRUE...

2. CO₂ SYSTEMS: HOW TO IMPROVE ENERGY EFFICIENCY



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- EFFICIENCY COMPARISON: CO₂ BOOSTER vs R404A DX IN DIFFERENT CLIMATES
- Application: RETAIL 150 kW MT - 30 kW LT (no heat recovery)



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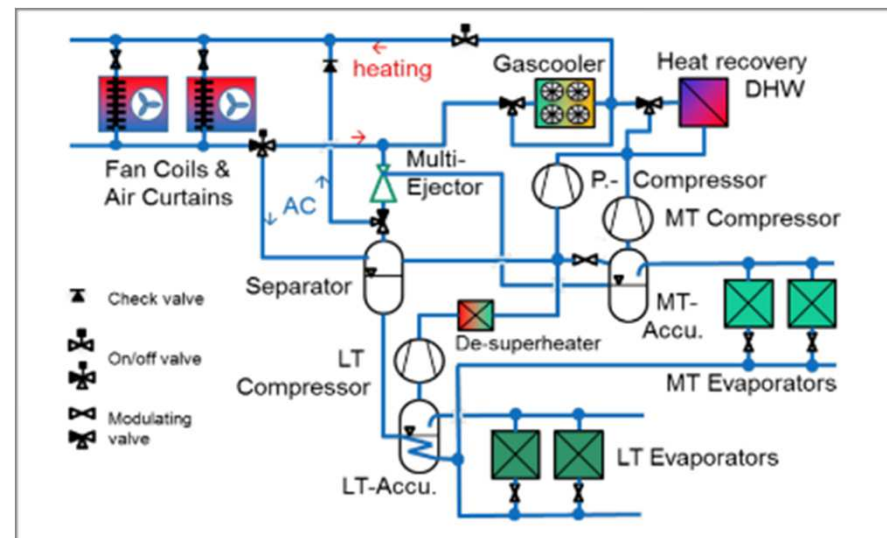


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TODAY ARE AVAILABLE TECHNOLOGIES THAT CAN SENSIBLY INCREASE THE SEASONAL EFFICIENCY OF TRANSCRITICAL BOOSTER SYSTEMS.

- PARALLEL COMPRESSION (PC)
- LIQUID EJECTOR (LEJ)
- VAPOR EJECTOR (VEJ)
- CLIMATIZACION MODULES (AC – CASSETTE SYSTEM DX)
- HEAT RECOVERY MODULES (HP - CASSETTE SYSTEM)



INTEGRATED SYSTEM WITH EJECTORS AND PARALLEL COMPRESSION

2. CO₂ SYSTEMS: HOW TO IMPROVE ENERGY EFFICIENCY

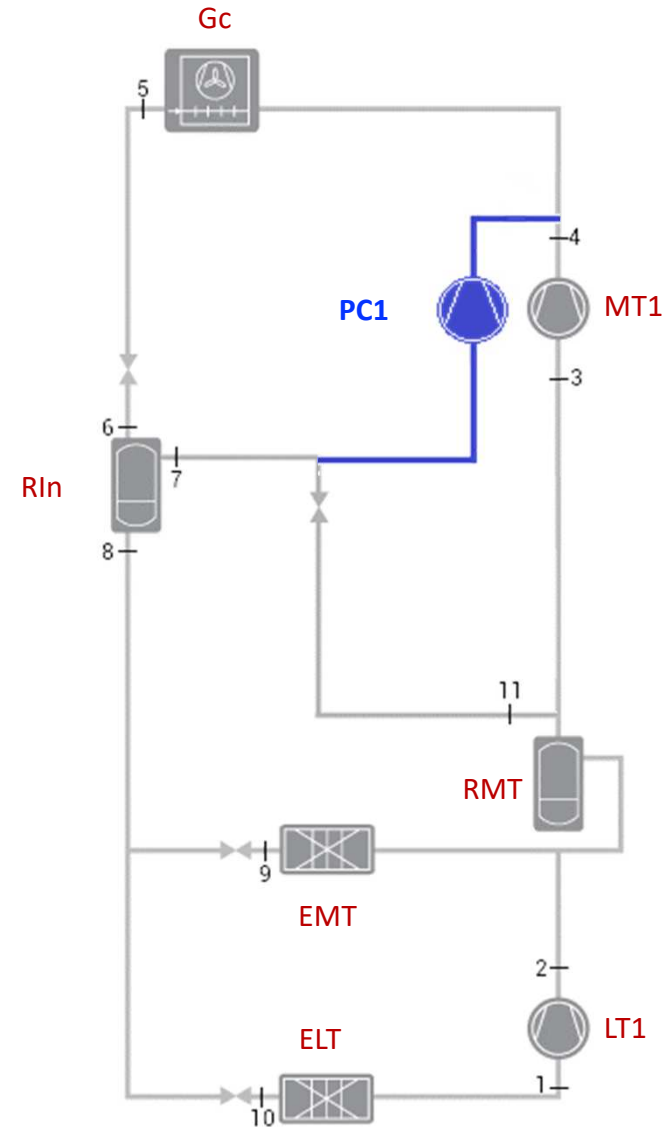
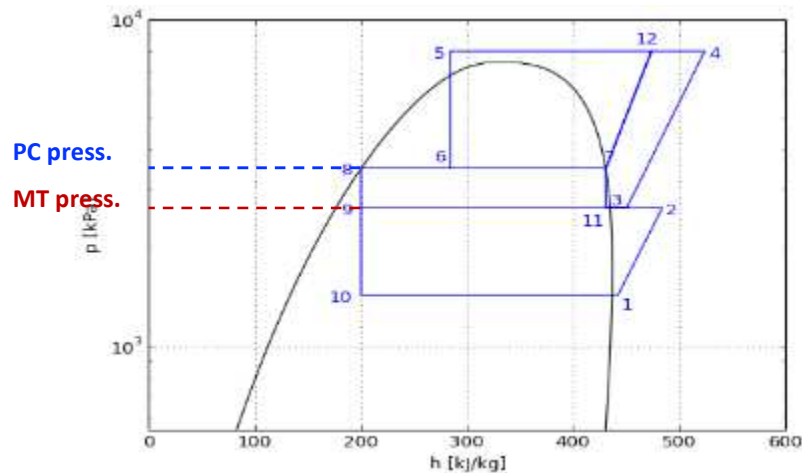


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- **PARALLEL COMPRESSION (PC)**

- ✓ FLASH GAS FROM INTERMEDIATE RECEIVERS IS PUMPED OUT AND COMPRESSED INTO THE GAS COOLER BY ONE (OR MORE) DEDICATED COMPRESSOR (PC)
- ✓ «PARALLEL» COMPRESSOR OPERATES AT AN HIGHER SUCTION PRESSURE THAN MT COMPRESSORS
- ✓ INCREASE IN COP



2. CO₂ SYSTEMS: HOW TO IMPROVE ENERGY EFFICIENCY

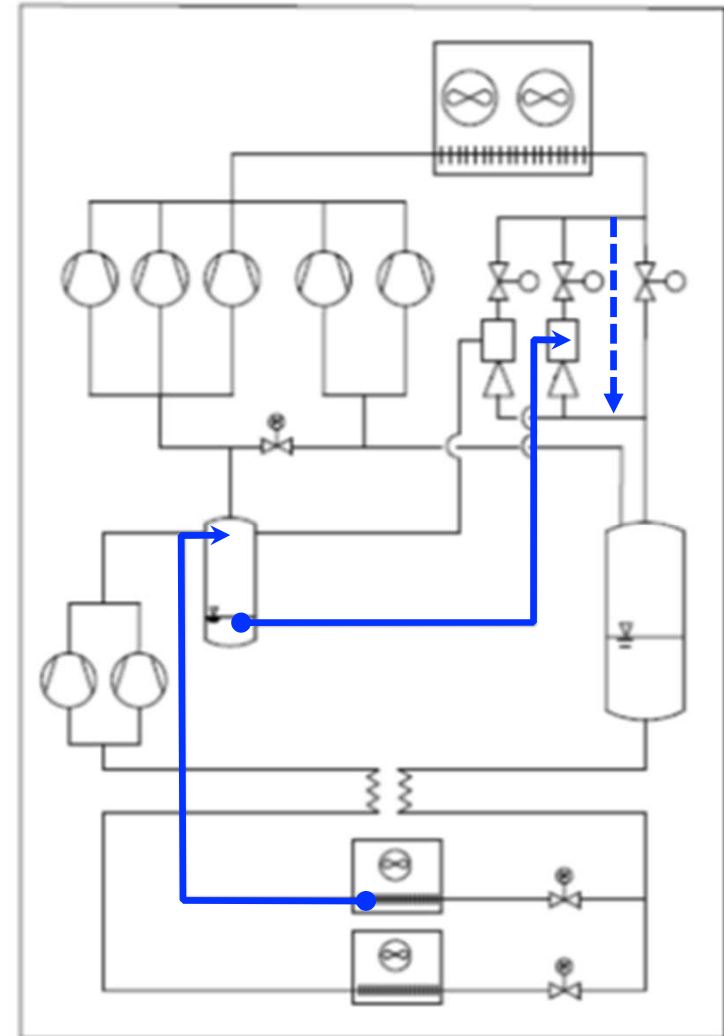


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- **LIQUID EJECTOR (LEJ) - OVERFEEDING EJ.**

- ✓ IT TAKE ADVANTAGE OF THE DELTA P BETWEEN GAS COOLER AND HIGH PRESSURE RECEIVER
- ✓ SUCKS EVENTUAL LIQUID IN EXCESS COMING FROM THE EVAPORATORS
- ✓ ALLOWS “OVERFED” OR “FLOODED” EVAPORATOR DESIGN
- ✓ MT EVAP TEMPERATURE CAN BE INCREASED UP TO 6K INCREASE
- ✓ LARGE COP INCREASE



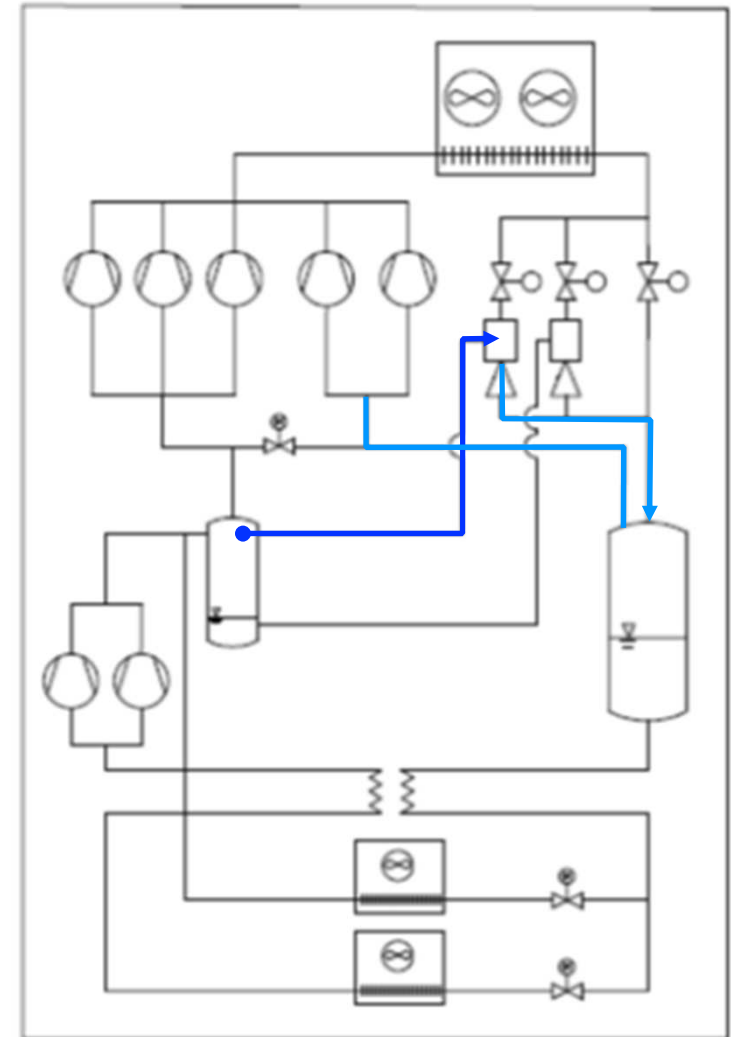
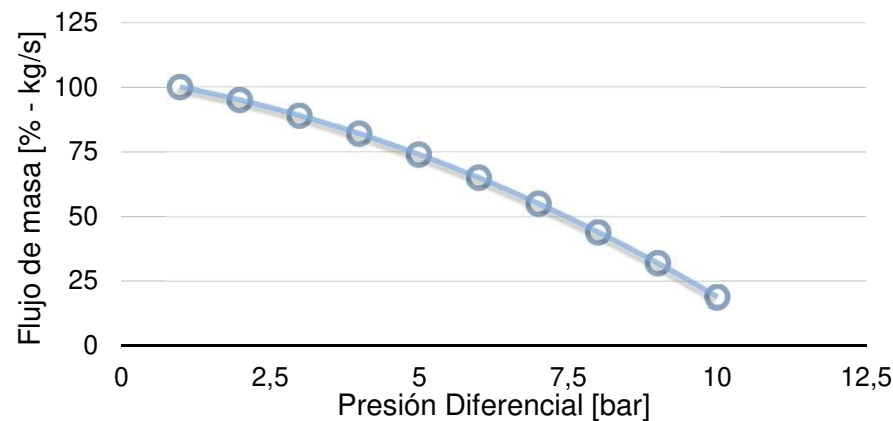
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- **VAPOR EJECTOR (VEJ) – PRE COMPRESSION EJ.**
- ✓ **FREE COMPRESSION FROM LOW PRESSURE RECEIVER TO MEDIUM PRESSURE RECEIVER**
- ✓ **LARGE INCREASE IN FLASH GAS QUANTITY**
- ✓ **NEED FOR LARGER PARALLEL COMPRESSORS**
- ✓ **WORKS MORE EFFICIENTLY ONLY IF IN CONJUNCTION WITH LIQUID EJECTORS**
- ✓ **MASS FLOW IS INVERSERLY PROPORTIONAL TO THE DIFFERENTIAL PRESSURE**



2. CO₂ SYSTEMS: HOW TO IMPROVE ENERGY EFFICIENCY



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ENERGY EFFICIENCY COMPARISON IN DIFFERENT CLIMATES WITH **ENHANCED BOOSTER CONFIGURATION**

EXAMPLE: SUPERMARKET 150 kW MT - 30 kW LT
CO₂ BOOSTER SYSTEM (PC+LEJ+VEJ) vs R404A DX



3. HYPERMARKET CARREFOUR IN ITALY



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3. HYPERMARKET CARREFOUR IN ITALY

- ✓ DUTIES : MT 340 kW - LT 66 kW
- ✓ HEAT RECOVERY FOR AMBIENT HEATING AND HOT SANITARY WATER
- ✓ MAX AMBIENT TEMP: 45°C - (WOULD WORK EVERYWHERE)
- ✓ 160 EVAPORATORS

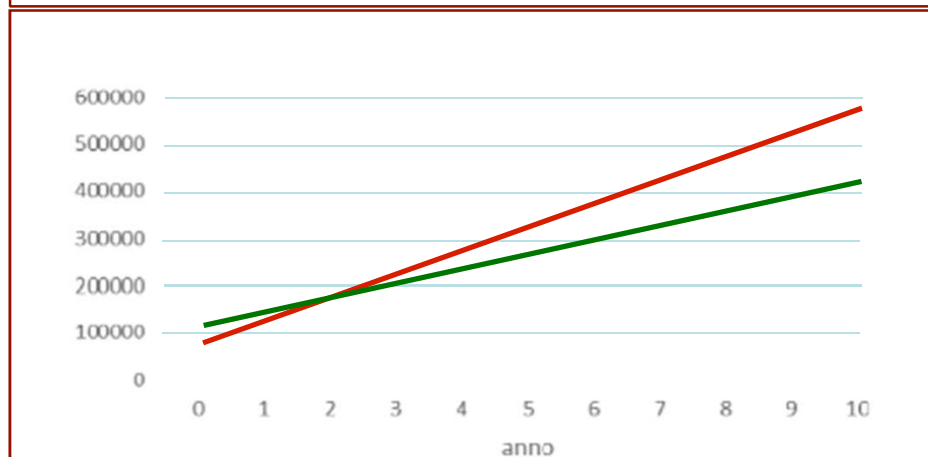
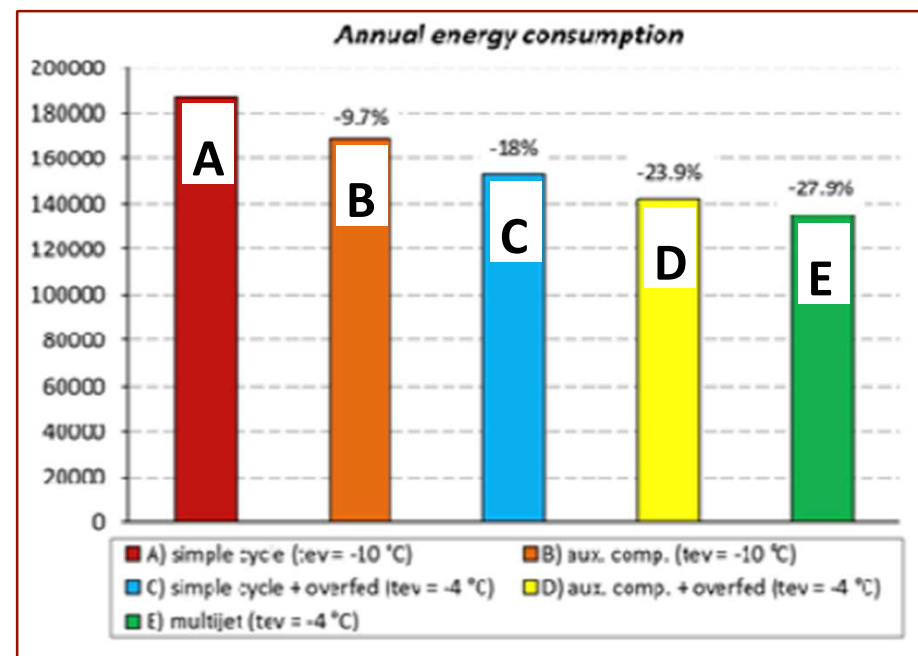
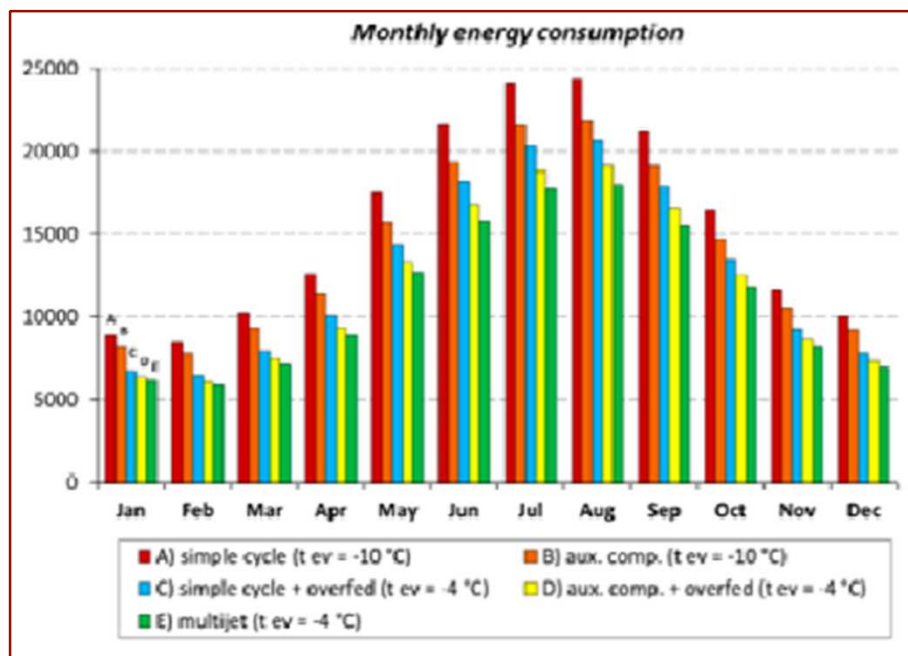


3. HYPERMARKET CARREFOUR IN ITALY



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A (FGB) vs E (PC+LEJ+VEJ) :

RETURN OF INVESTMENT: 2 YEARS

4. CONCLUSIONS



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- TODAY THERE ARE HUNDREDS OF INSTALLATIONS WITH PARALLEL COMPRESSION AND EJECTORS
- THE USE OF EJECTORS AND PARALLEL COMPRESSION HAS PROVEN THEIR EFFICIENT AND RELIABLE OPERATING ALSO IN HOT CLIMATES SINCE 2013, AND HAS PERMITTED THAT CO₂ INSTALLATION WOULD BE MORE EFFICIENT SOLUTION THAN TRADITIONAL HFC SYSTEMS AT ANY LATITUDE
- THIS TECNOLOGY CAN BE CONSIDERED MATURE AND AVAILABLE IN THE MARKET.

***“CO₂ IS AS CLOSE TO THE IDEAL
REFRIGERANT AS IT IS POSSIBLE TO COME”***

1993 - prof. GUSTAV LORENTZEN



4. CONCLUSIONS: Other references in hot climate

INDUSTRIAL PLATFORM FRAGADIS

The largest transcritical CO₂ installation in Spain

MT Duty: 2x 435 kW --- LT Duty: 2x 134 kW



Very compact rack thanks to Dorin CD500 series compressors
the largest in the market with 59,35 m³/h displacement
Competitor's largest model is 38,2 m³/h

+56% in displacement!!

170 kW @ -10 ev. temp. / 60 bar

120 kW @ -10 ev. temp. / 90 bar (gas cooler out temp 36°F)



4. CONCLUSIONS: Other references in hot climate

PINGO DOCE Supermarket 1800 m²

Beja – Portugal

MT duty: 113,3 kW --- LT duty: 19,1 kW

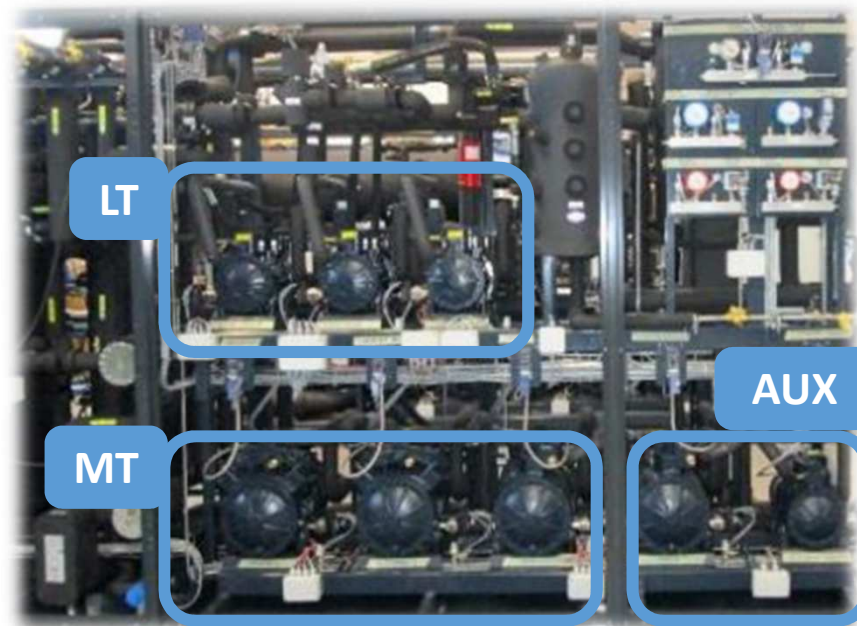


4. CONCLUSIONS: Other references in hot climate

AL SALAM Supermarket, Amman (Jordan)

38 kW @-25°C, 69 kW@-2°C

FIRST transcritical CO₂ supermarket in Middle East



- Parallel compression + ejectors
- Heat recovery for sanitary water

5. 2-Stage compressors vs Screw Compressors



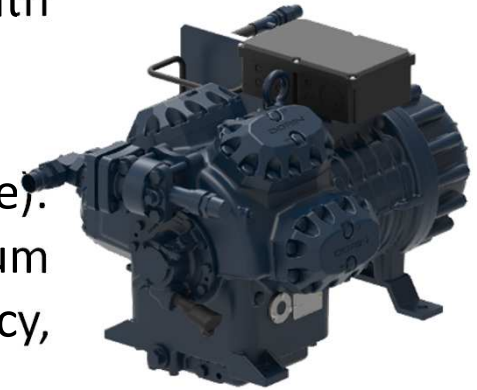
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In LT applications is very common to use Screw compressors with Economizer but they seems to have a really poor efficiency.

Dorin, for this applications, offers 2S-H7 range:

2 stage reciprocating, 8 cylinders - 65 Hp - 183,58 m³/h (1st stage).

This large size 2-stage compressors are comparable to medium size screw compressors but with much higher efficiency, especially with high Condensing Temperature



DORIN - SUBCOOLING MODE - R404A -45°C / +50 °C				BITZER - ECONOMIZED MODE - R404A -45°C / +50 °C			
MODEL	Q	P	COP	MODEL	Q	P	COP
2S-H2000	14,1	13,7	1,03	HSN5343-20	12,3	26,0	0,47
2S-H2500	15,6	15,5	1,01	HSN5353-25	15,1	30,0	0,50
2S-H3000	18,5	18,4	1,01	HSN5363-30	18,9	35,1	0,54
2S-H4000	21,6	22,0	0,98	HSN6451-40	22,9	39,9	0,57
2S-H5000	26,7	22,8	1,17	HSN6461-50	26,7	46,6	0,57
2S-H6000	30,6	26,9	1,14	HSN7451-60	30,8	60,2	0,51
2S-H6500	32,7	29,4	1,11	HSN7461-70	36,1	62,0	0,58

...and efficiency is just one of the several advantages you can achieve!

5. 2-Stage compressors vs Screw Compressors

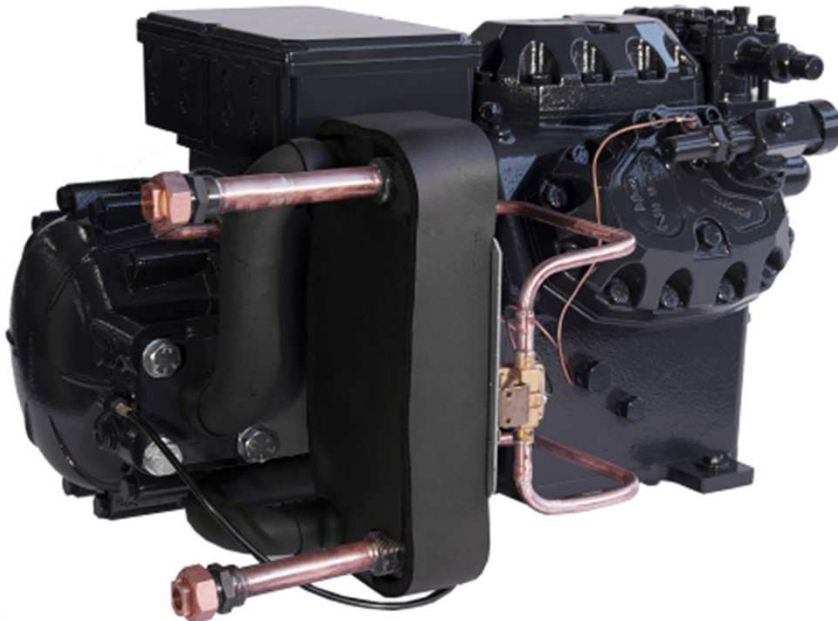


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ECONOMIZERS:

- 2-STAGE COMPRESSORS
 - BUILT-IN ECONOMIZER
 - SIMPLE
 - COMPACT
 - READY TO USE



- SCREW COMPRESSORS
 - EXTERNAL ECONOMIZER
 - MORE COMPLICATED
 - MORE EXPENSIVE



5. 2-Stage compressors vs Screw Compressors



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COMPLICATE AND EXPENSIVE OIL CIRCUIT:

- SCREW COMPRESSORS OIL COOLERS (+ 3 WAY VALVE - ...)



- ICS VALVE + CVP CONTROL FOR PROPER OIL FLOW AT START-UP



- VERY LARGE oil separator
(HSN7461-70 @-45°C/50°C
pumps 38 l/min of oil !!!)

5. 2-Stage compressors vs Screw Compressors



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COMMENTS

Using 2-stage reciprocating compressors instead of screws, in LT applications, shows several advantages:

- Much higher efficiency
- Better management of high DeltaP
- Liquid subcooler included and pre-assembled on compressor
- No need of large oil separators
- No need of oil cooling circuit
- Less components and less labour
- Very compact dimensions
- Larger application envelope
- Lower noise level
- Easily repairable

