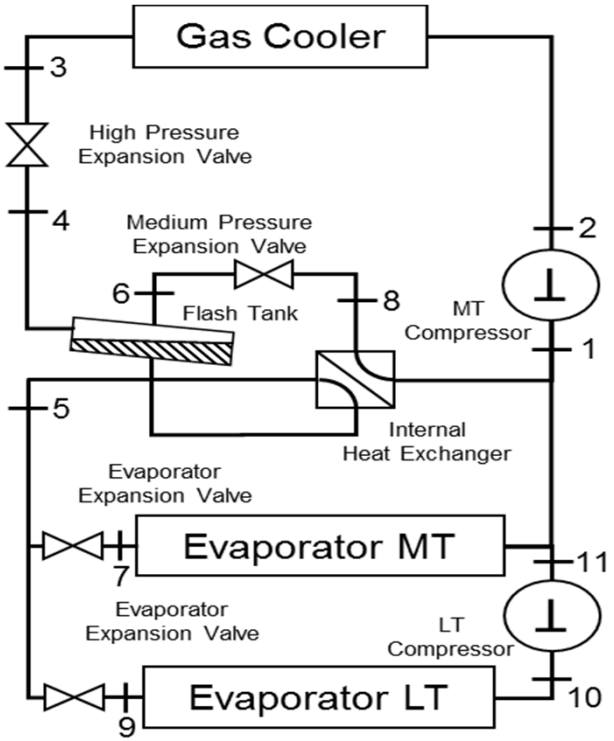
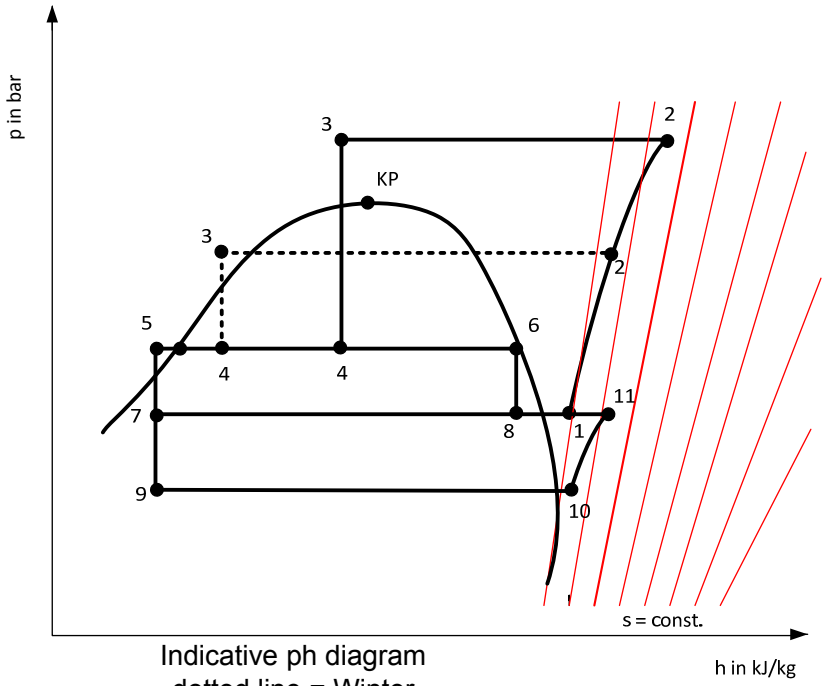
The next generation of commercial CO_2 refrigeration systems

Speaker : Sascha Hellmann, Engineering Project Leader Mechanical Systems

INTRODUCTION

Typical transcritical CO_2OLtec® booster system

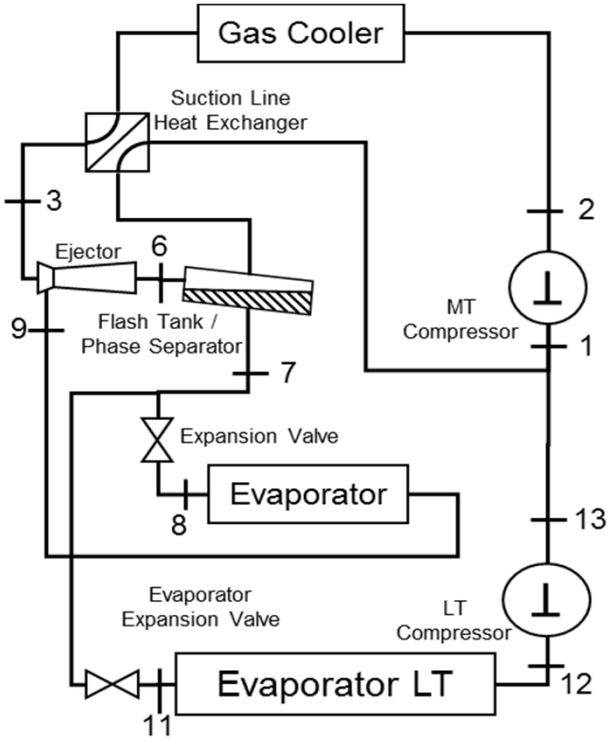


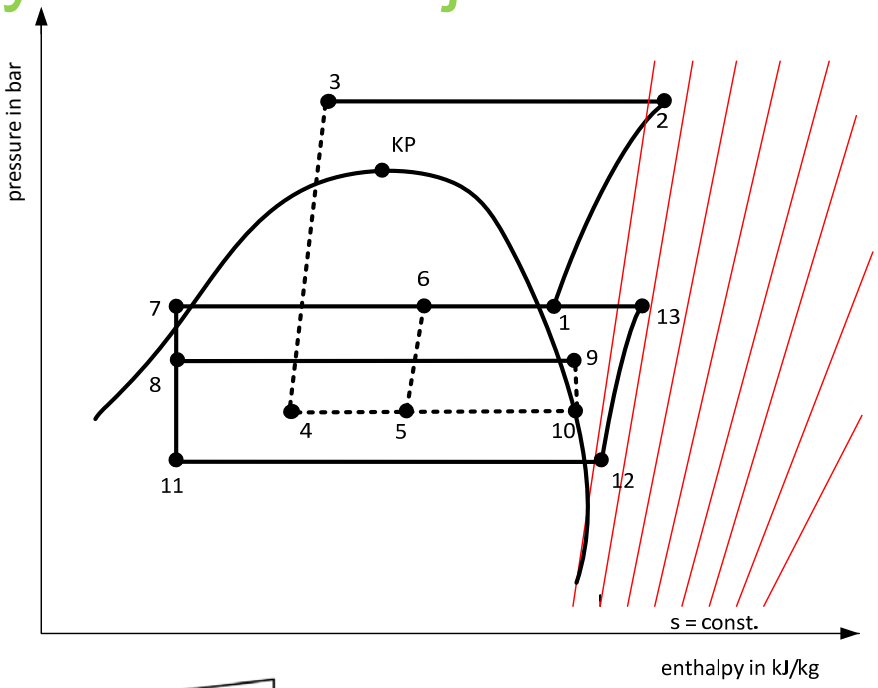


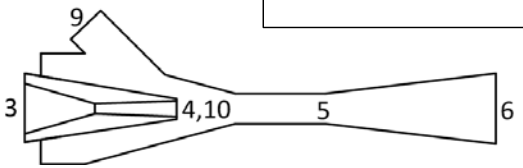
Indicative ph diagram
dotted line = Winter
solid line = Summer

EJECTOR SYSTEM

Transcritical CO_2OLtec system with ejector





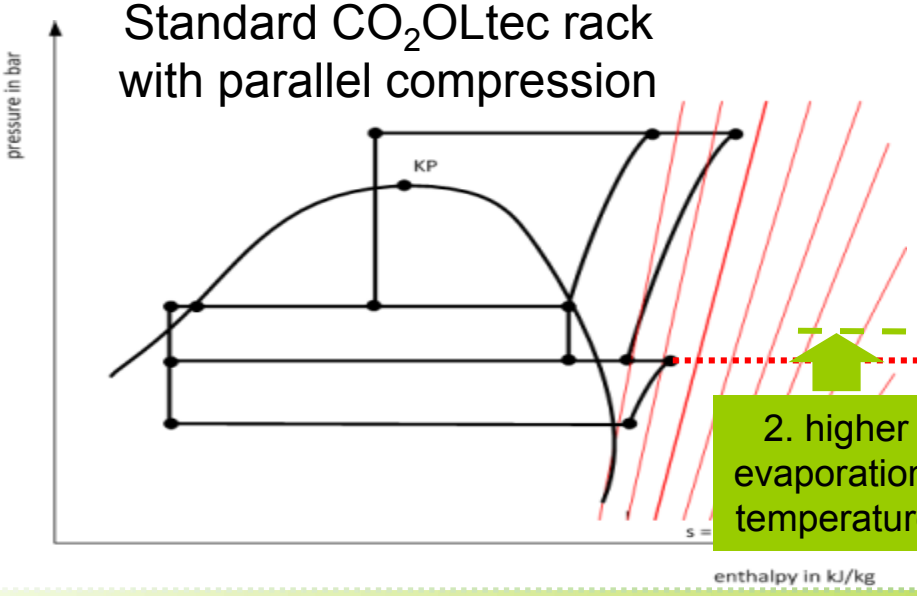


Indicative ph diagram
dotted line inside the ejector

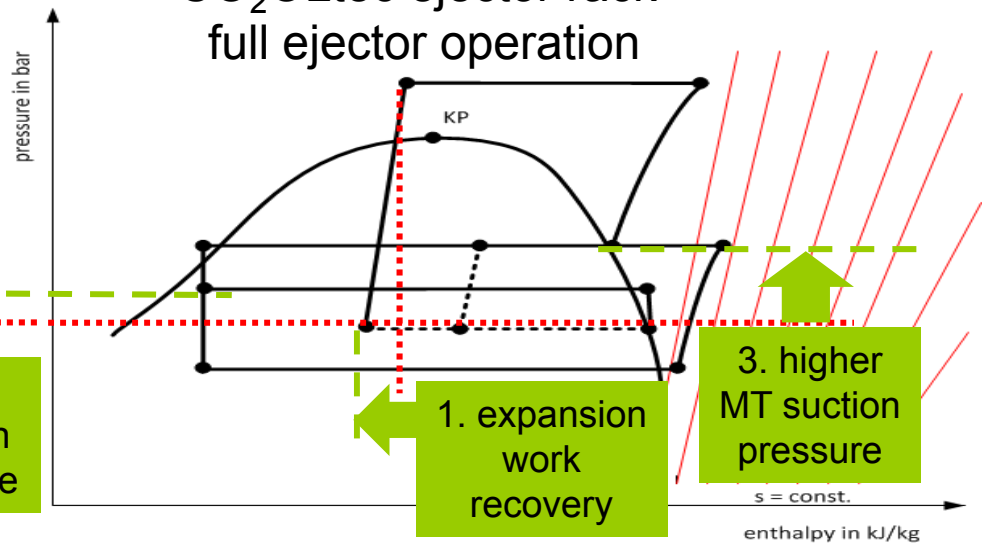
CYCLE IMPROVEMENT

Why is it more efficient?

Standard CO_2OLtec rack with parallel compression



CO_2OLtec ejector rack full ejector operation



1. Expansion work recovery — EFFICIENCY INCREASE
2. Higher evaporation temperature in MT cabinets — EFFICIENCY INCREASE
3. Higher suction pressure at all MT compressor — EFFICIENCY INCREASE

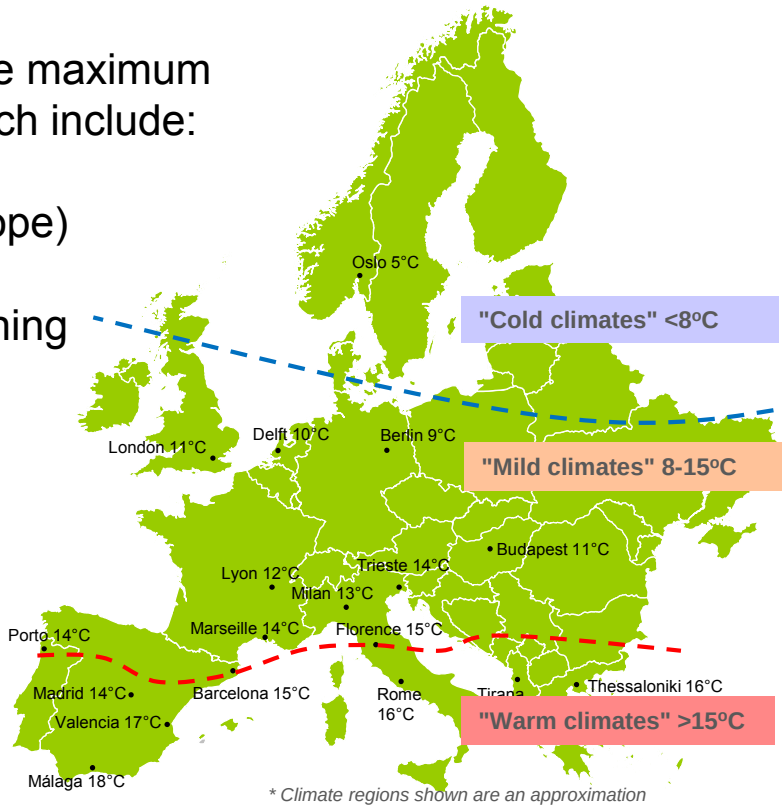
NEXT GEN CO_2OLtec OVERVIEW

What is the aim?

The aim of the Carrier adjustable ejector is to provide maximum energy savings[1] during high pressure conditions, which include:

- Operation in **warm climates** (e.g. Southern Europe)
- Operation in **mild climates**
- Operation in **cold climates**, when system is running in **gas cooler bypass** heat recovery mode (e.g. Northern Europe)

Energy savings dependent on technology, application and climate.

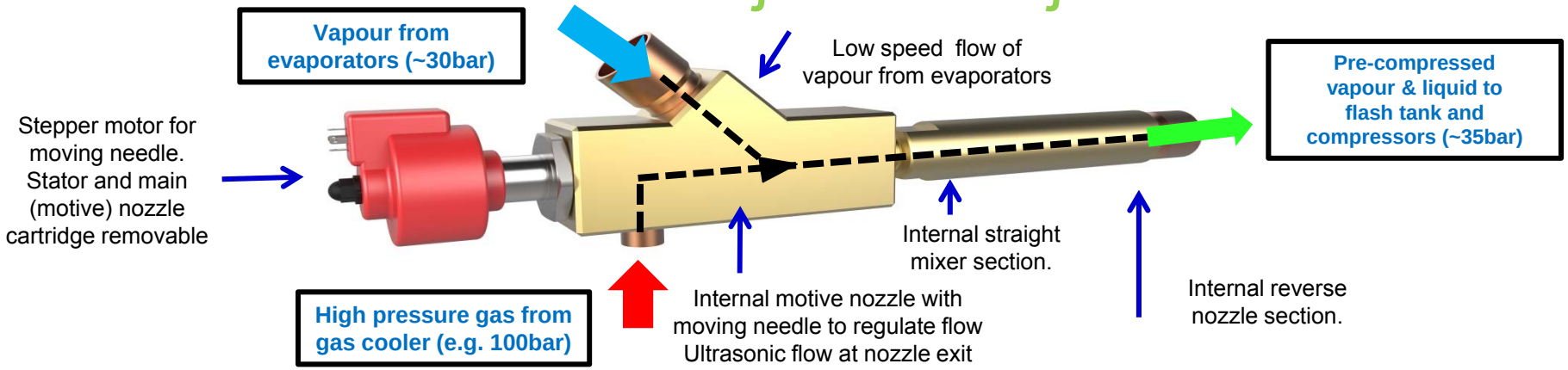


** Climate regions shown are an approximation*

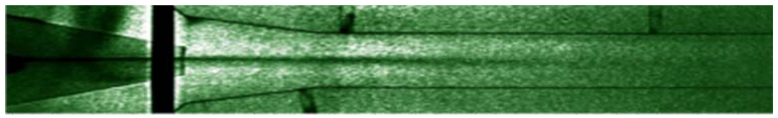
[1]The ejector may be installed in combination with other features to maximize annual energy efficiency such as economizer, pumps, etc…

ADJUSTABLE EJECTOR OVERVIEW

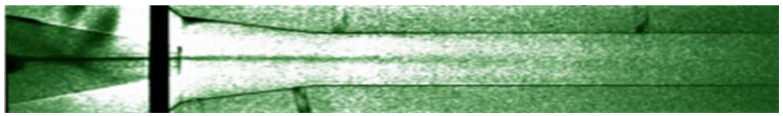
How does the Carrier adjustable ejector work?



Two Phase Neutron Imaging[1]



High ΔP, high entrainment



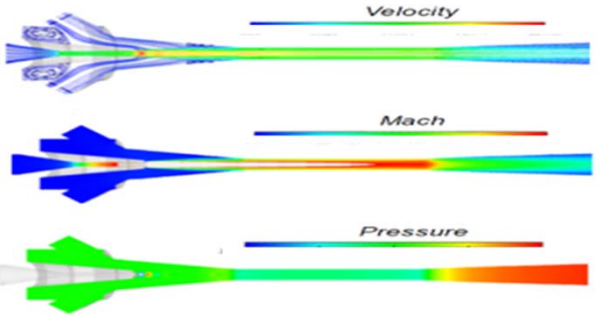
Low ΔP, high entrainment

CFD Analysis

Step 1: convert pressure → velocity

Step 2: suck & accelerate suction flow

Step 3: convert velocity → pressure



[1]Source: United Technologies Reaserch Center
Oak Ridge National Laboratory

ADJUSTABLE EJECTOR

Field trial status

- Measuring operational performance, efficiency and reliability
- >20 ejectors delivered to date
- Field trials in operation since October 2014
- Projects in Spain, France, Netherlands, Switzerland

CO_2 BOOSTER WITH EJECTOR

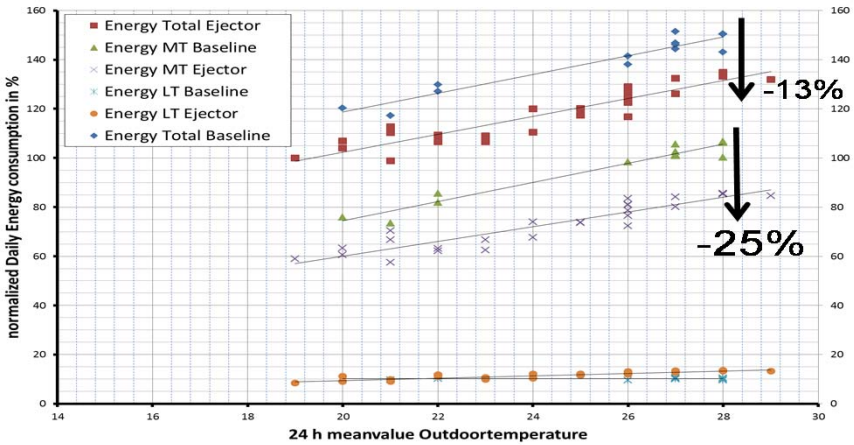
Field trial: performance results

Measurement results for daily energy consumption (24h) during summer operation

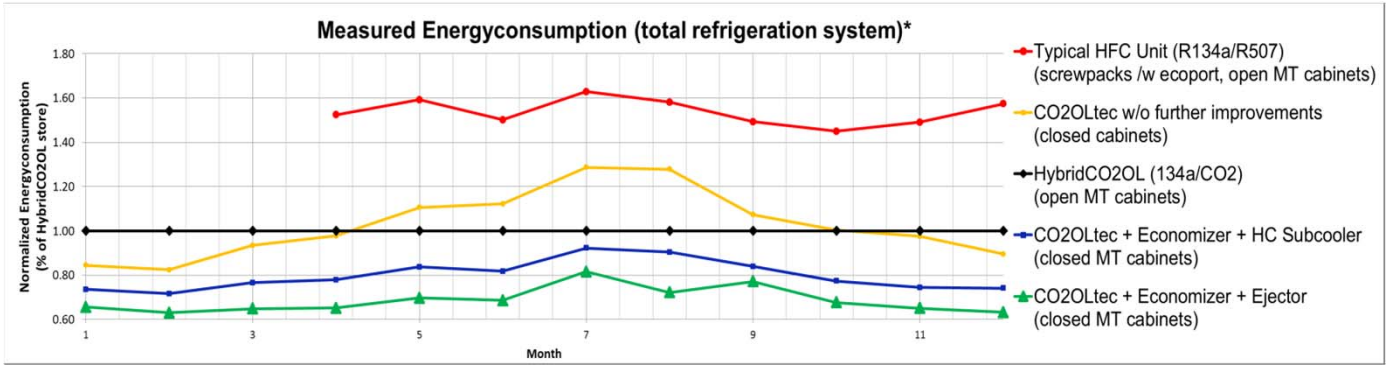
Operation with/without ejector for comparison

Reduced energy consumption in ejector operation mode @ 28°C vs. CO_2OLtec standard:

-25% MT compressor rack
-13% total refrigeration system[1]



y-axis normalized, Total Energyconsumption Ejector @19°C = 100%



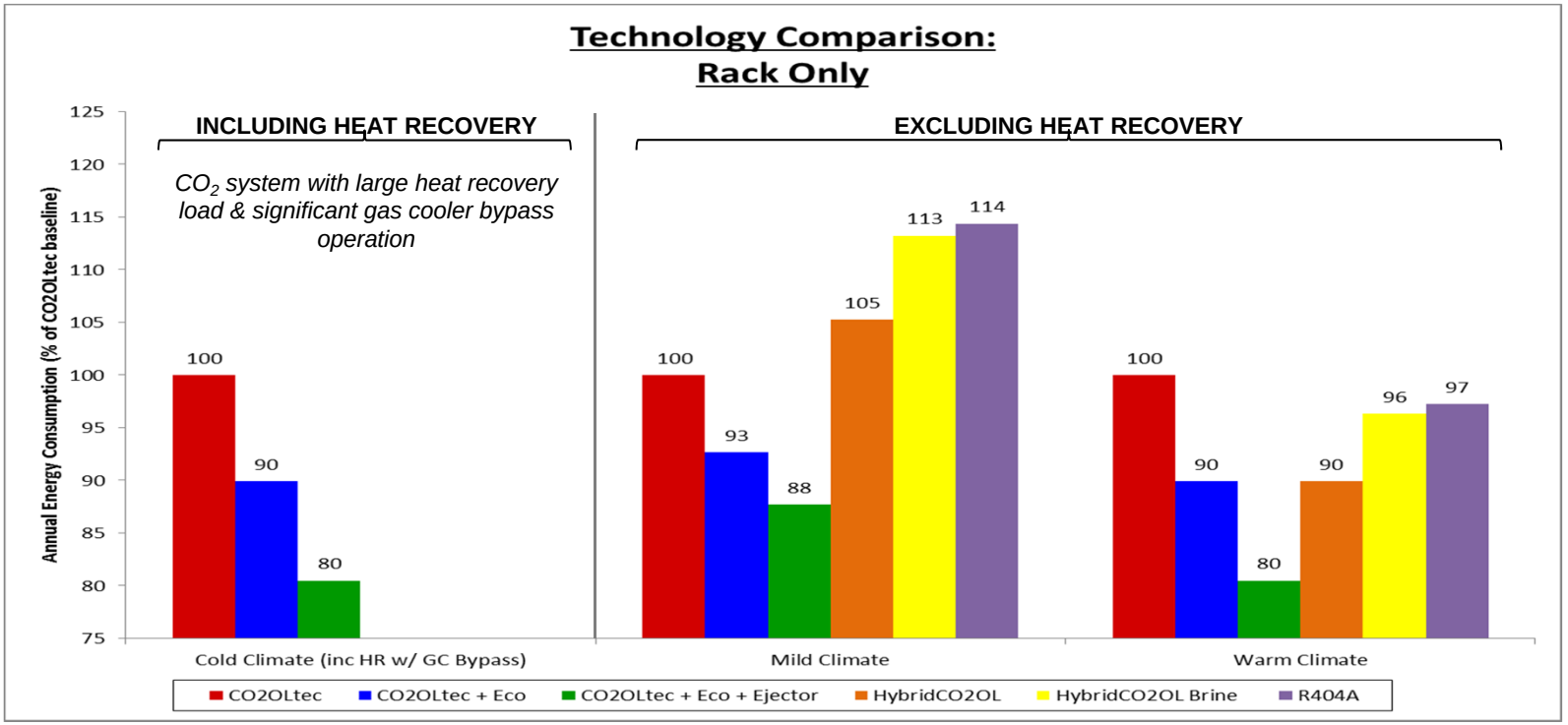
*The graph on the left hand side gives an indication of what is possible.

Please consider:
The stores presented are similar in size, layout and location, however they are not exactly the same.

[1] MT + LT Rack + Gascooler + Cabinets fans/light/defrost

SAVING ENERGY: RACK

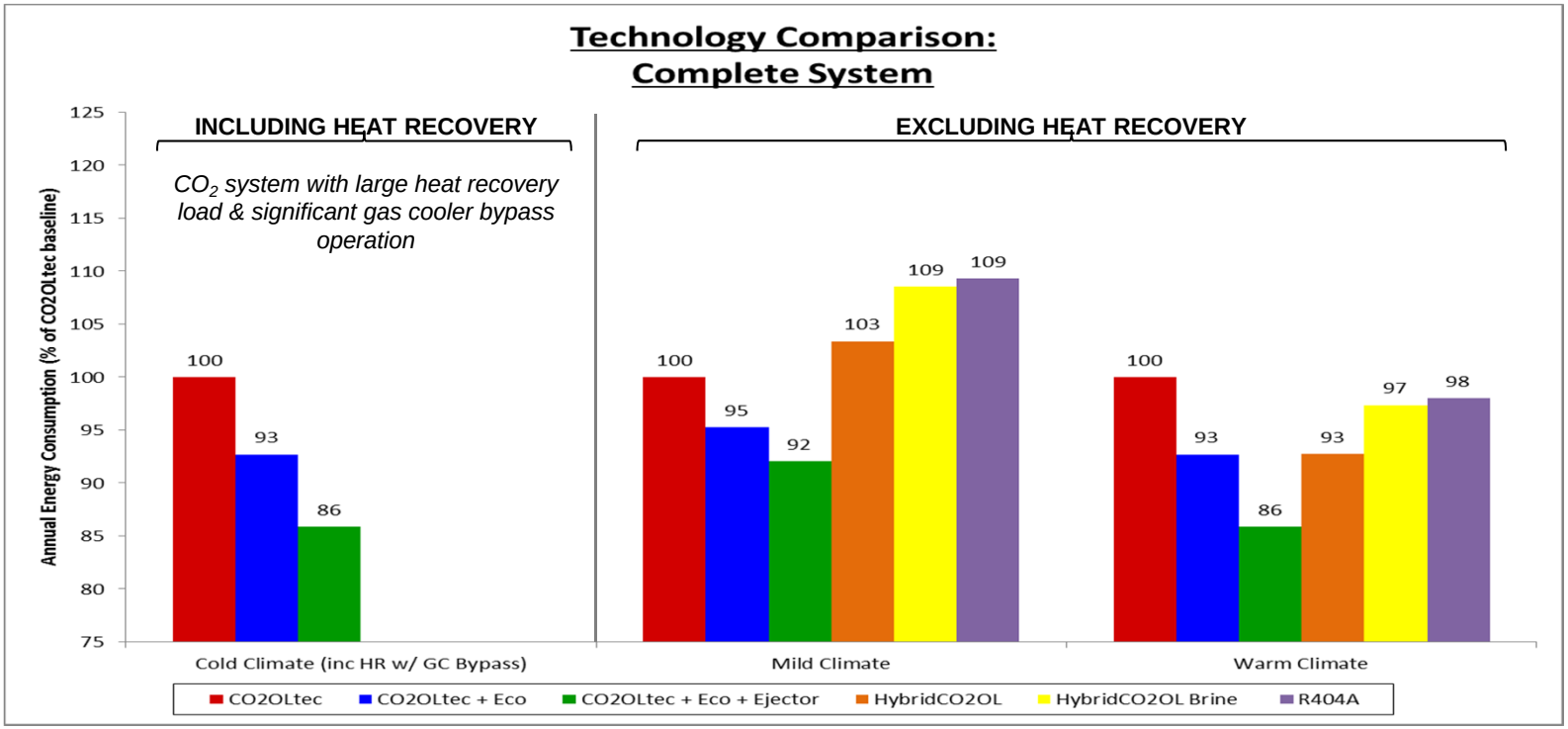
What energy savings can be expected?



*Projected simulation based on 94m MT cabinets, 38m LT cabinets, 228m³ MT coldroom, 55m³ LT coldroom. MT cabinets /w glass doors, EC fans, LED lighting.. (Carrier e*cube).*
Temperature profiles: Warm Climate = Average Seville, Athens, Barcelona & Madrid; Mild Climate = Berlin; Cold Climate = Average Oslo, Stockholm, Helsinki
HybridCO2OL = CO2 LT + R134a MT

SAVING ENERGY: COMPLETE SYSTEM

What energy savings can be expected?



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Temperature profiles: Warm Climate = Average Seville, Athens, Barcelona & Madrid; Mild Climate = Berlin; Cold Climate = Average Oslo, Stockholm, Helsinki
HybridCO2OL = CO2 LT + R134a MT

SUMMARY

Optimized transcritical CO_2 solutions

WARM Climate (>15°C average)
Energy modelling shows an annual saving potential[1] of up to 20% for the rack, or 14% for a complete store, versus standard CO_2OLtec[2]
Installations of vapor ejector systems w/o other features shows measured annual saving[3] for the complete store of:

- >13% vs. CO_2OLtec
- >7% vs. CO_2OLtec + Economizer.

This matches well with the simulated values.

MILD Climate (8°C - 15°C average)
Energy modelling shows an annual saving potential[1] of up to 12% for the rack, or 8% for a complete store, versus standard CO_2OLtec[2]. ***With additional technologies modelling indicate potential rack energy savings of up to 20%.***

COLD Climate (<8°C average)
Energy modelling shows an annual saving potential[1] of up to 20% for the rack, or 14% for a complete store, versus standard CO_2OLtec[2] with large heat recovery load & significant gas cooler bypass operation.

Carrier provides optimized energy solutions with sustainable refrigeration technologies for every food retail store format

[1]Based on economizer + ejector cycle
*[2]Projected simulation based on 94m MT cabinets, 38m LT cabinets, 228m³ MT coldroom, 55m³ LT coldroom, MT cabinets /w glass doors, EC fans, LED lighting.. (Carrier e*cube).*
[3]Measured values in a real store based on 178m MT cabinets, 75m LT cabinets & 1143m³ MT coldrooms, 320m³ LT coldroom

ACKNOWLEDGEMENTS

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