EXPO FRIO CALOR CHILE

CHILE 2018

Eficiencia energética en sistemas que utilizan CO_2 como refrigerante natural

SCM FRIGO

A BEIJER REF Company

Ministerio del Medio Ambiente

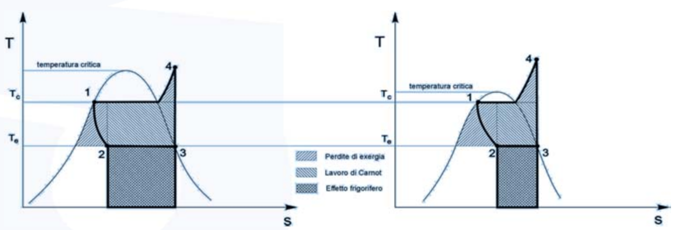
Gobierno de Chile

EXPO FRIO CALOR CHILE

ONUDI

CO_2 Transcritical Cycle Efficency Optimization

The use of CO_2 as the sole refrigerant has been mainly limited to temperate climates; as a matter of fact, both efficiency and refrigeration capacity of the transcritical single compression cycle undergo a rapid deterioration in hot climates.

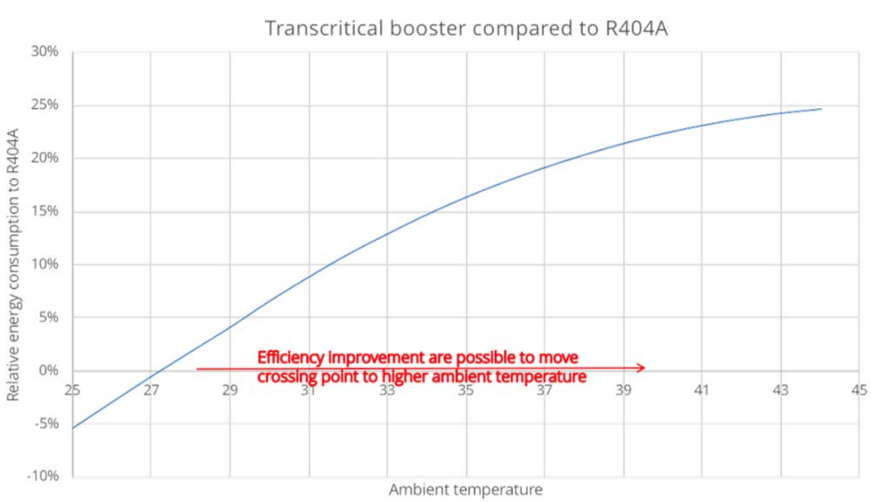


There are different option today to reduce the efficiency losses and improve the efficiency of a transcritical cycle, using indirect or direct methods:

Indirect:
Adiabatic systems
Mechanical subcooling

Direct:
Parallel compression
Vapor ejector
Liquid ejector

CO_2 Transcritical Cycle Efficency Optimization



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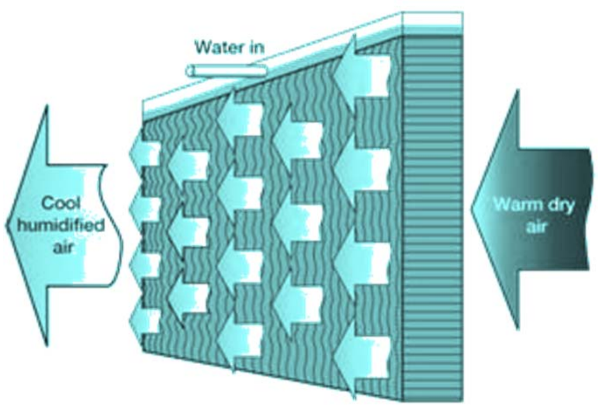
CO_2 Transcritical Cycle Efficency Optimization: Adiabatic systems

To improve the CO_2 cycle efficiency there is the possibility to increase the gas cooler efficiency by humidifying the air flow trough the gas cooler.

This is possible using different technologies with increased efficiencies:

- **Spray system**
- **Gas cooler with adiabatic Panels**
- **Adiabatic gas cooler**



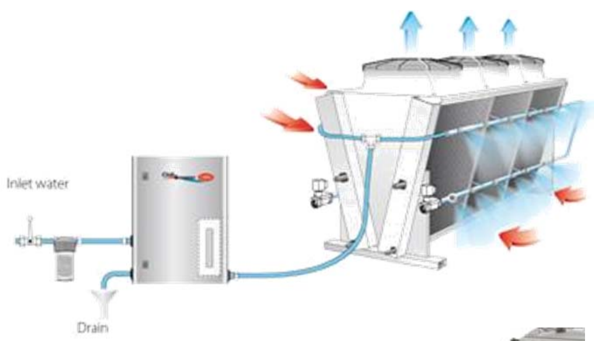
The higher is the ambient humidity the higher will be the wet bulb temperature of the air outlet an therefore lower will be the efficiency of the adiabatic system.

A reasonable limit of application of this technology would be RH no more than 60% (tipically 40 to 60%)

CO_2 Transcritical Cycle Efficency Optimization: Spray systems

Is the most common and easy way to reduce the air inlet temperature on the gas cooler humidifying the air flow entering the gas cooler coil. This is realize using nozzle that nebulise water at high pressure in the air flow.

Pros: simple installation and easy management
Cons: not high efficiency, scale formation on the coil if water is not treated, coil fin treatment is required.



CO_2 Transcritical Cycle Efficency Optimization: Adiabatic Panels

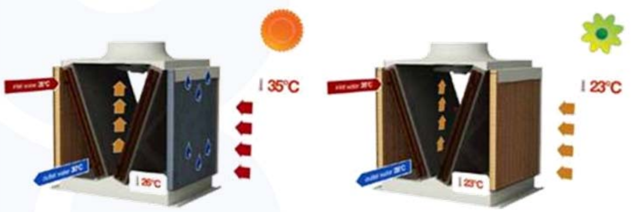
The gas cooler is equipped with vertical panels installed on the air inlet side.

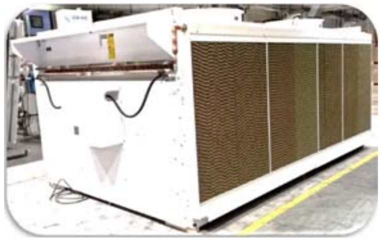
These panels are humidified with water coming form the top of the panel and the air is efficiently humidified and consequently cooled before to reach the gas cooler coil . Water never reach the coil.

The gas cooler can be design as dry gas cooler and panels can be installed as options.

Pros: Hi efficiecy system, no need of fin coil treatment, no need of water treatment, can be used wihout time limitation.

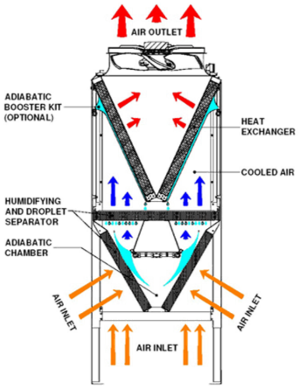
Cons: more expensive, more demanding in maintenance





CO_2 Transcritical Cycle Efficency Optimization: Adiabatic Gas Cooler

Adiabatic Gas cooler:
The adiabatic gas cooler maximize the adiabatic effect combining the panels and the spray system.
This kind of gas cooler should be design as adiabatic gas cooler since the beginning.
Fin coil treatment and water treatment is required.

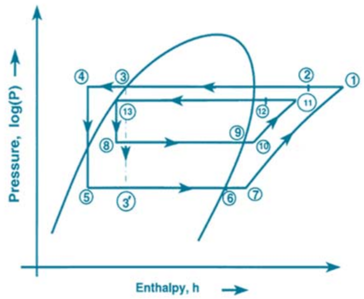


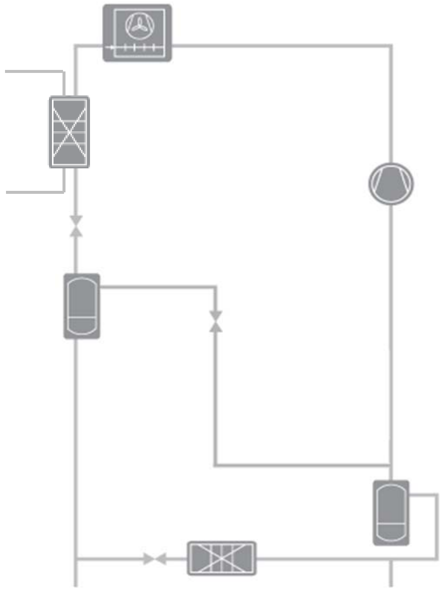
CO_2 Transcritical Cycle Efficency Optimization: Mechanical Subcooler

Reducing throttling losses: Mechanical Subcooling

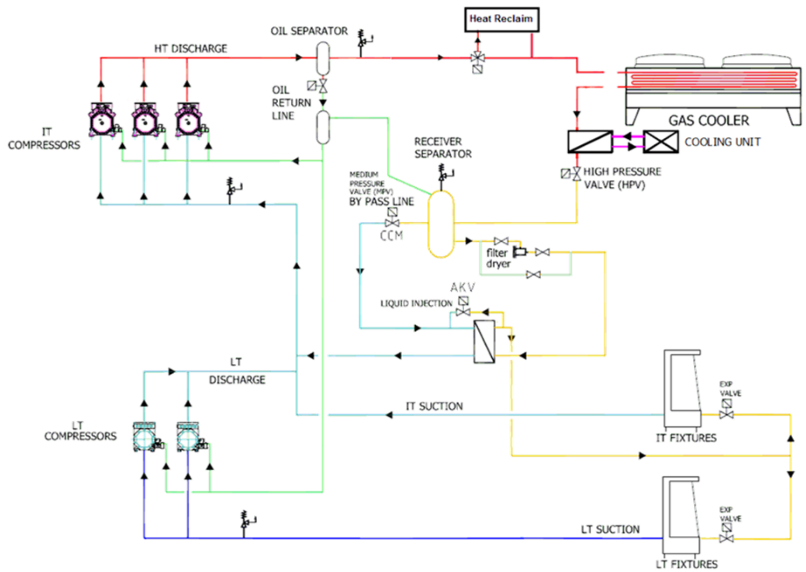
The mechanical subcooling solution strongly reduces exergy trottling losses thus increasing the overall system energy efficency.

Thermodinamically further cooling of refrigerant leaving the gas cooler or condenser can significatelly reduce power consumption and improve the system COP.



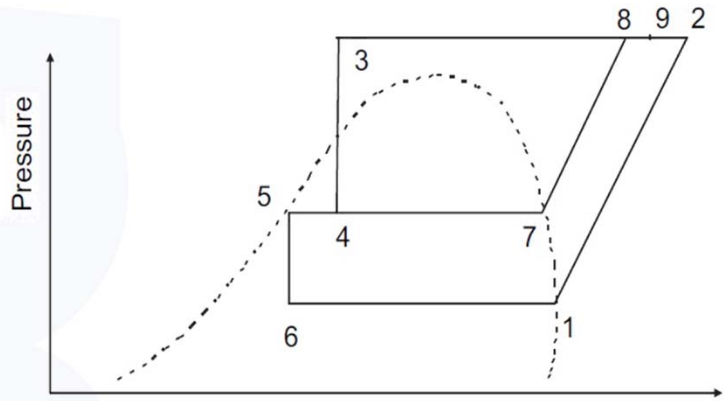


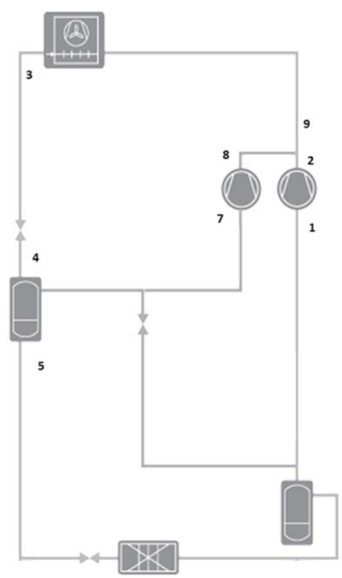
CO_2 Transcritical Cycle Efficency Optimization: Mechanical Subcooler



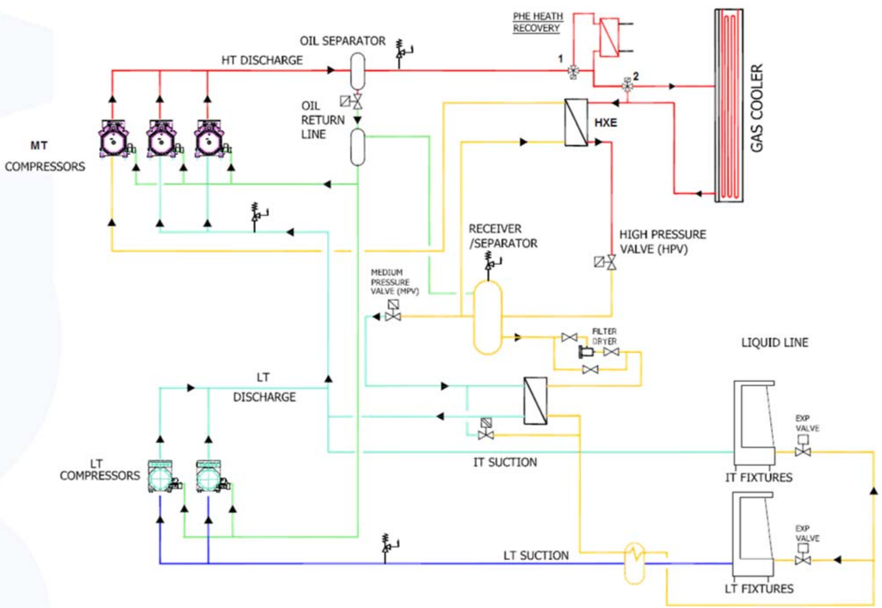
CO_2 Transcritical Cycle Efficiency Optimization: Parallel compression

Improved cycles have been proposed to enhance efficiency and cooling capacity at high ambient temperature mainly reducing exergy throttling losses.



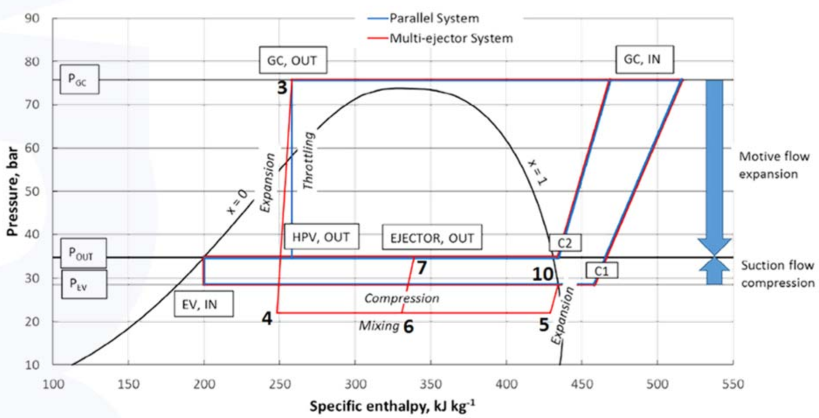


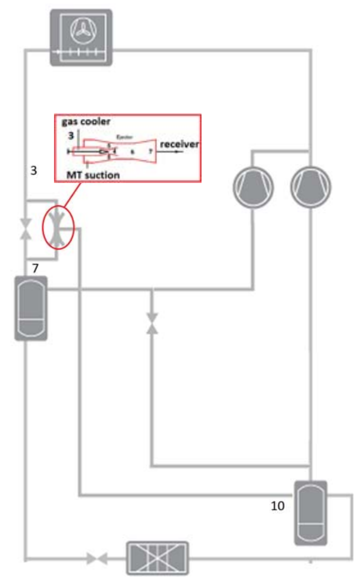
CO_2 Transcritical Cycle Efficiency Optimization: Parallel compression



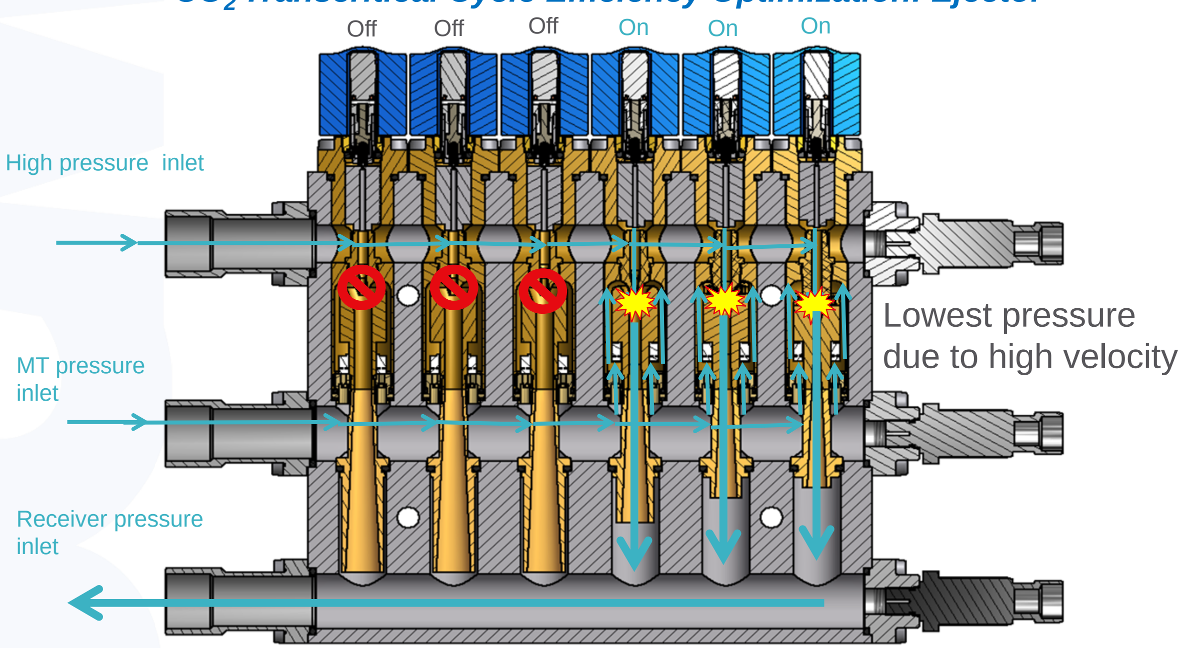
CO_2 Transcritical Cycle Efficiency Optimization: Ejector

The ejector is a component that expands a high-pressure primary substance to absorb a secondary substance at a pressure slightly above the low pressure reached by the primary substance.





CO_2 Transcritical Cycle Efficiency Optimization: Ejector



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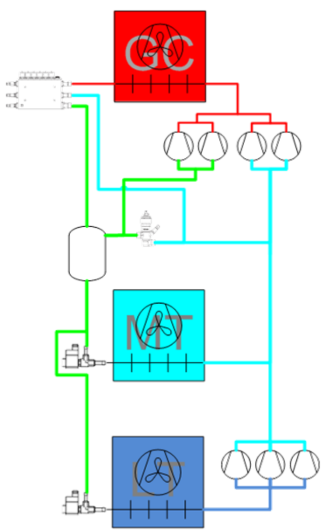
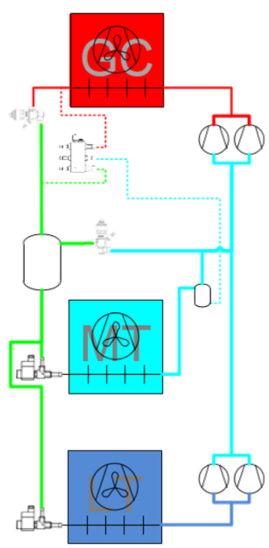
CO_2 Transcritical Cycle Efficiency Optimization: Ejector

Vapour Ejector application



Liquid Ejector application



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CO_2 Transcritical Cycle Efficiency Optimization: Vapor Ejector

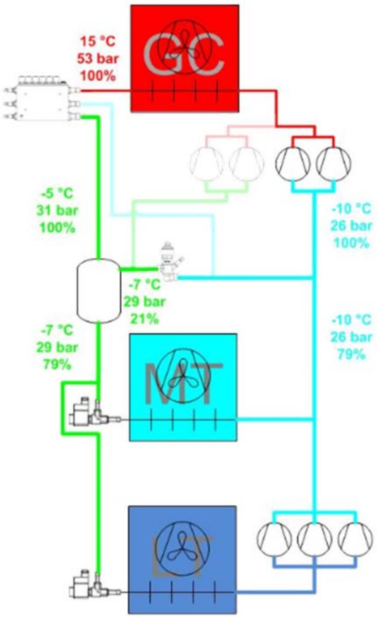
High pressure lift ejectors are always used in systems with parallel compression.

The high pressure ejector system in cold temperature mode is operating like a booster system.

The gas bypass valve is taking the flash gas from the receiver and putting the gas to the MT compressors.

The gas from the gas by pass valve is mixed with gas from MT evaporators and from the LT compressors and compressed with the MT compressors that needs to be able to compress enough gas to handle the capacity in this situation.

The ejector will in this mode just work as a high pressure valve and adjust the high pressure according to the normal algorithm.



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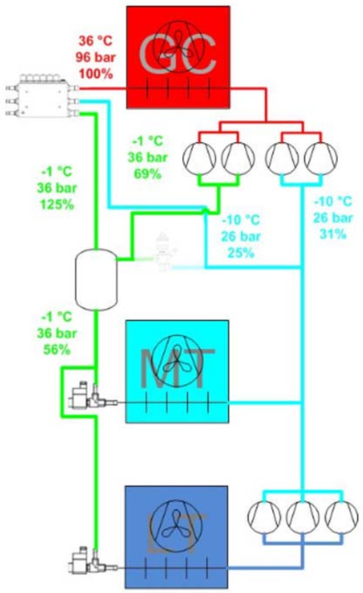
CO_2 Transcritical Cycle Efficiency Optimization: Vapor Ejector

When the temperature out of gas cooler is warmer the ejector starts to pump.

The gas from MT is pumped through the ejector and is lifted to the receiver where it is separated with the gas from the expansion.

The liquid flows to the evaporators and the gas is moved to the parallel compressors where it is compressed.

The parallel compressor will do approx. 75% of the total flow and the MT compressors will do the remaining 25%.



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CO_2 Transcritical Cycle Efficiency Optimization: Liquid Ejector

Liquid ejectors can be used on all transcritical CO2 systems and is used to remove gas from the suction accumulator.
Enegy data shows savings of approx 10%

Liquid ejectors can be added to any type of system (booster, LP and HP ejector systems)

The flooding of the evaporators is managed by the case/evap controller and the amount of liquid coming back from the evaporators is approx. 1-5%.

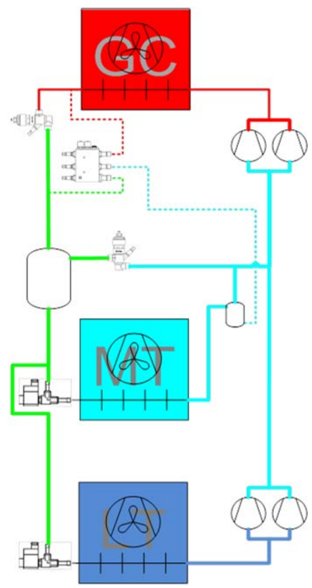
Liquid is collected in the suction accumulator and the gas is passed on to the MT compressors.

The liquid ejector is pumping the liquid from a low point in the suction accumulator back to the receiver.

The liquid ejectors can give a lift of 5 bar even at very low high pressures (down to 45 bar).

In case the ejector can not pump the liquid the evaporators is asked to return to DX mode.

In case of LP and HP ejectors present in the system a common suction from the suction accumulator is used and the gas ejectors will pump the liquid in warn periods due to higher efficiency.



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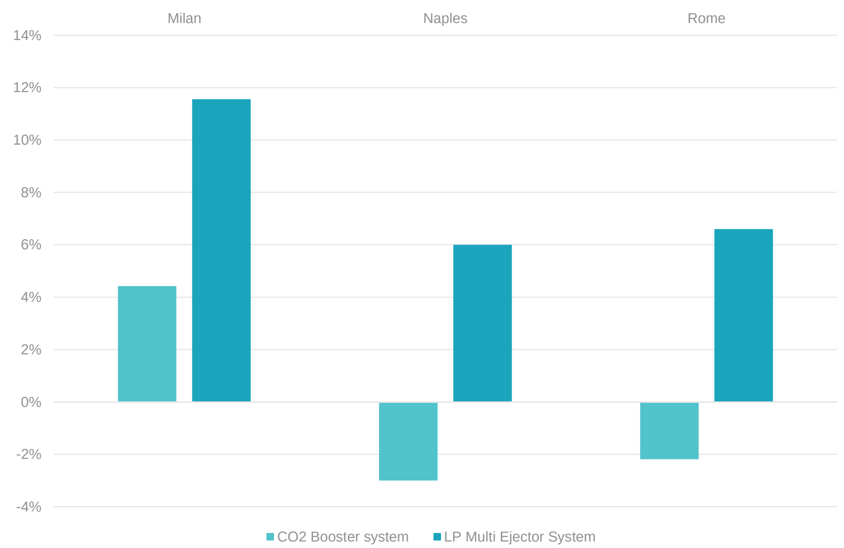
CO_2 Transcritical Cycle Efficiency Optimization: Efficiency Comparison

R404A VS CO2 systems (liquid and Vapor Ejector)



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Thank You!