Cost effective solution for smaller size CO_2 commercial refrigeration systems utilizing ejector technology

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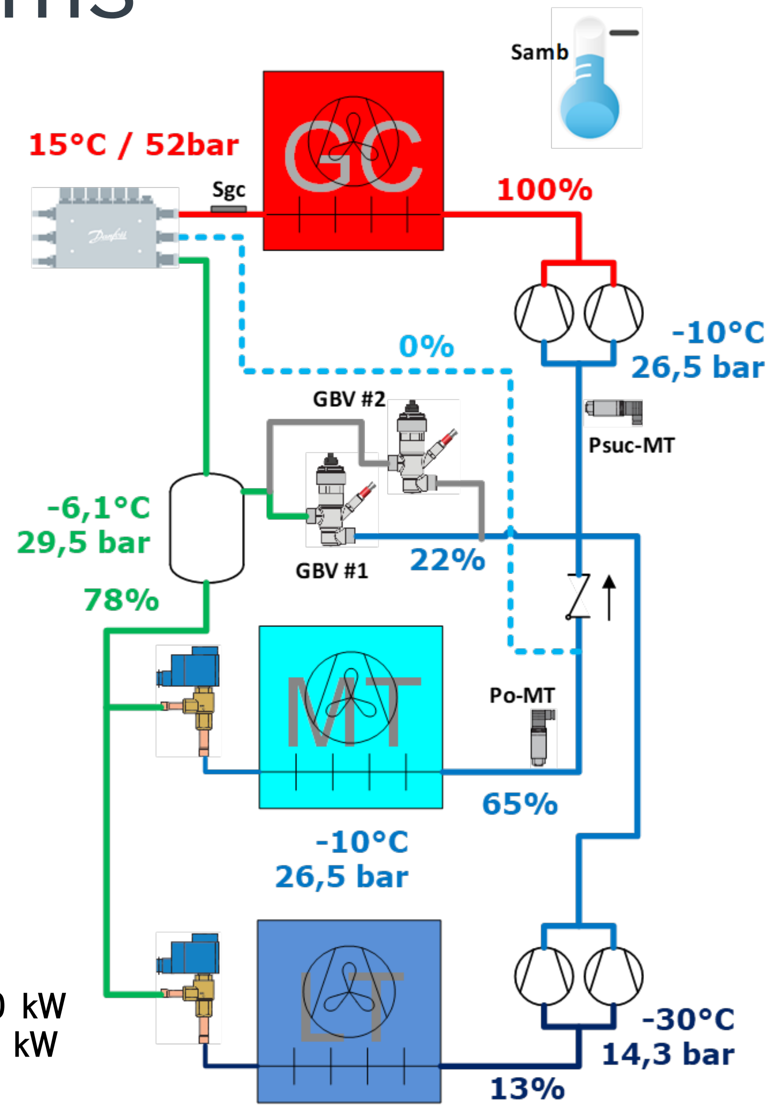
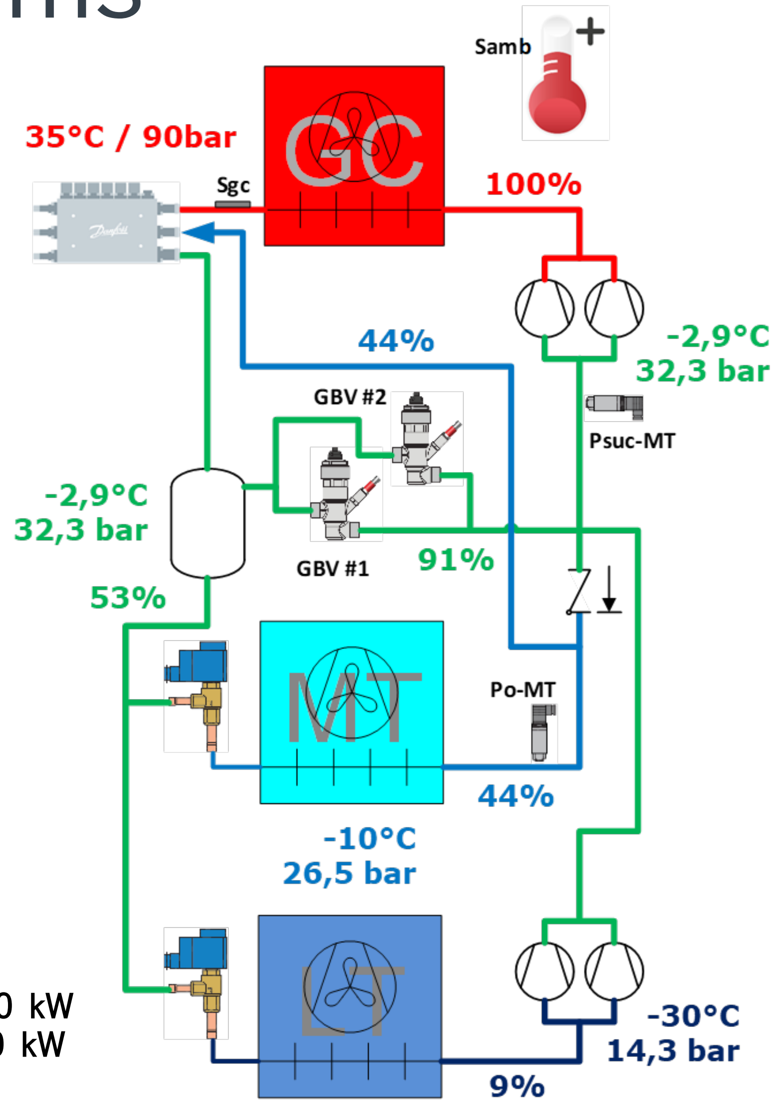
LP ejector and simple systems

- In cold temperature mode the gas coming from LT compressor and MT evaporators is sucked through the Check Valve in the suction line and mixed with gas from gas by pass valve. The ejector is not capable of lifting the gas from evaporator.
- In winter mode the ejector is simply controlling the high pressure as a high pressure valve.
- The flow from the ejector will flow to the receiver where liquid and gas from expansion is separated and the gas flows through the gas by pass valve to the MT compressors and the liquid is expanded to the evaporators.
- In winter mode the system operates like a normal booster system.



LP ejector and simple systems

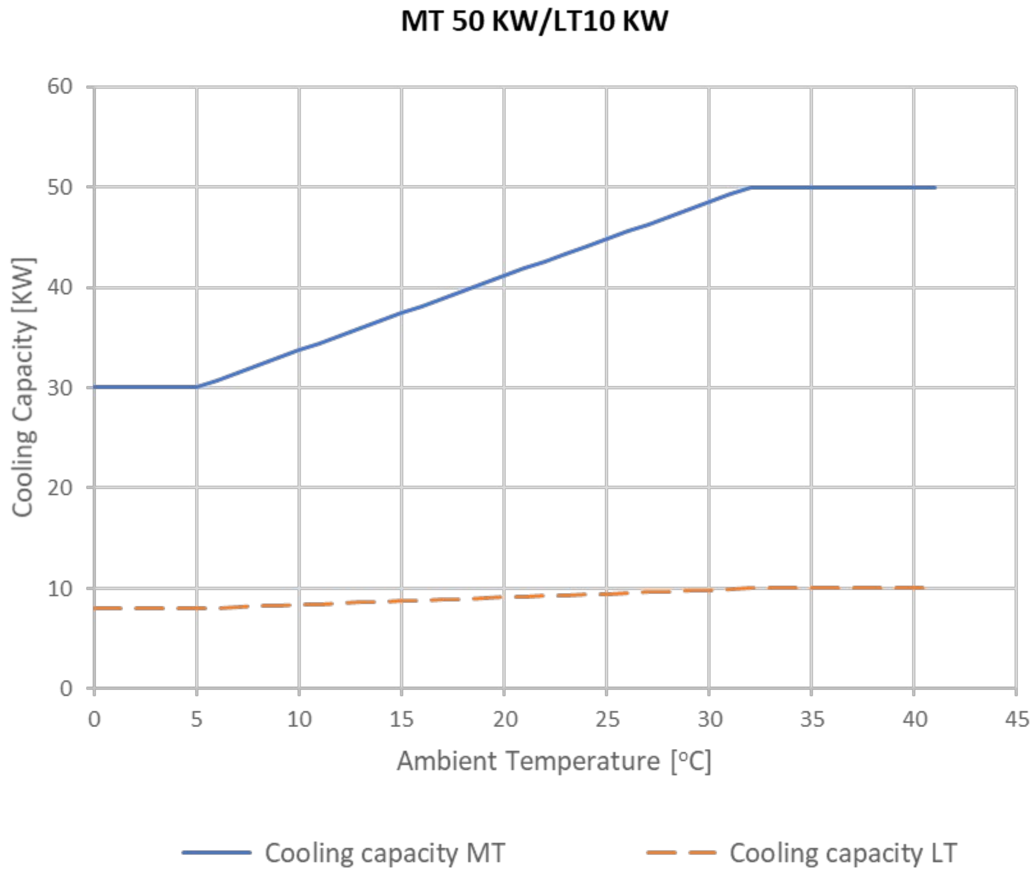
- In warm temperature mode the temperature out of the gas cooler is high and corresponding optimal pressure in GC is high too, so ejector is capable of lifting all the gas from MT evaporators through the ejector and to the receiver (check valve in suction line between compressors and evaporators is closed due to pressure difference).
- In the receiver the gas and liquid is separated and the liquid is expanded in the evaporators and the gas flows through the gas by pass valve, which is fully open and has a very low pressure difference.
- The compressors is sucking the gas directly from the receiver and compressing to the high pressure. The flow is then cooled in the gas cooler and expanded in the ejector.



MT evap load 50 kW
LT evap load 10 kW

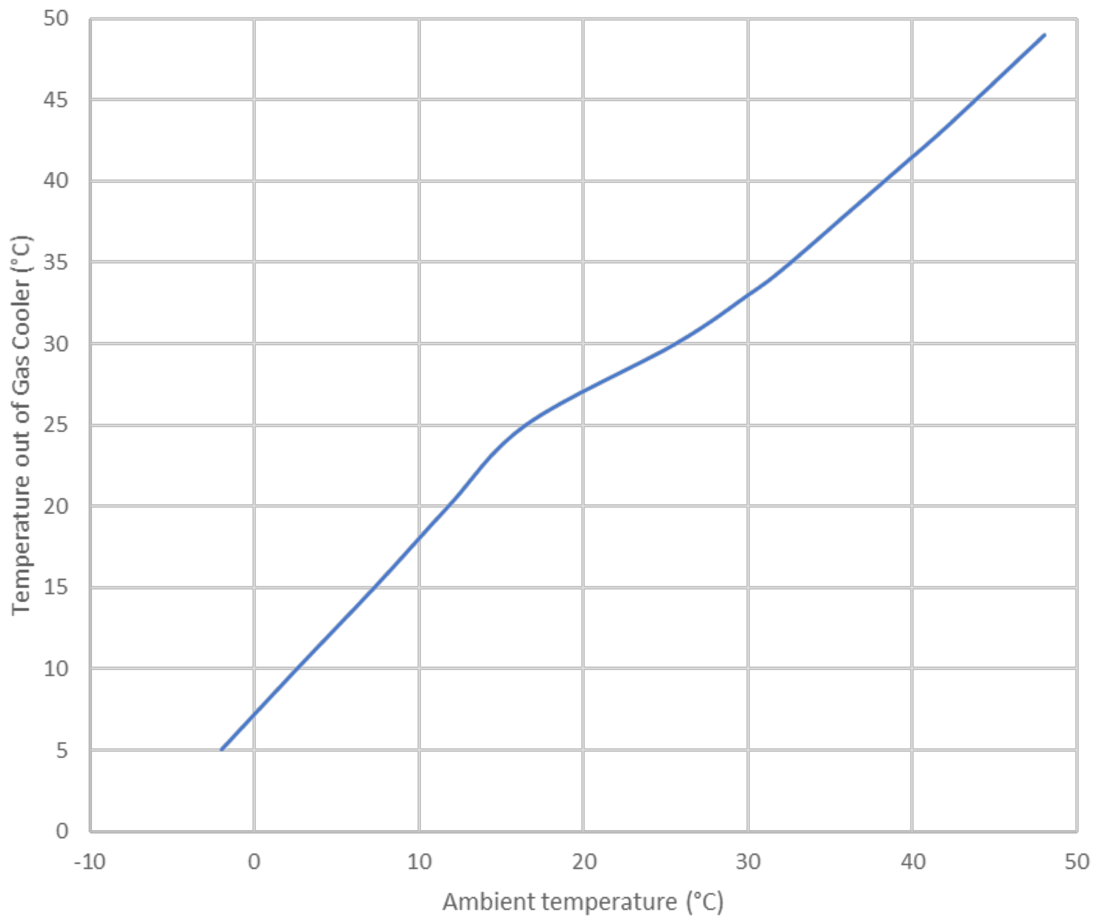
System Analysis

- The benchmark system is considered a standard CO_2 booster system with a high pressure valve, a gas by pas valve and the receiver pressure controlled by a constant pressure difference 3 bar
- Design cooling load for MT and LT specified for ambient temperature 32°C
- Cooling load varying with the ambient temperature according to the SEPR - EN13215
- Three load variations ware calculated:
- MT: 50 KW, LT:20, LT/MT=0.4
- MT: 50 KW, LT:10, LT/MT=0.2
- MT: 50 KW, LT:0, LT/MT=0

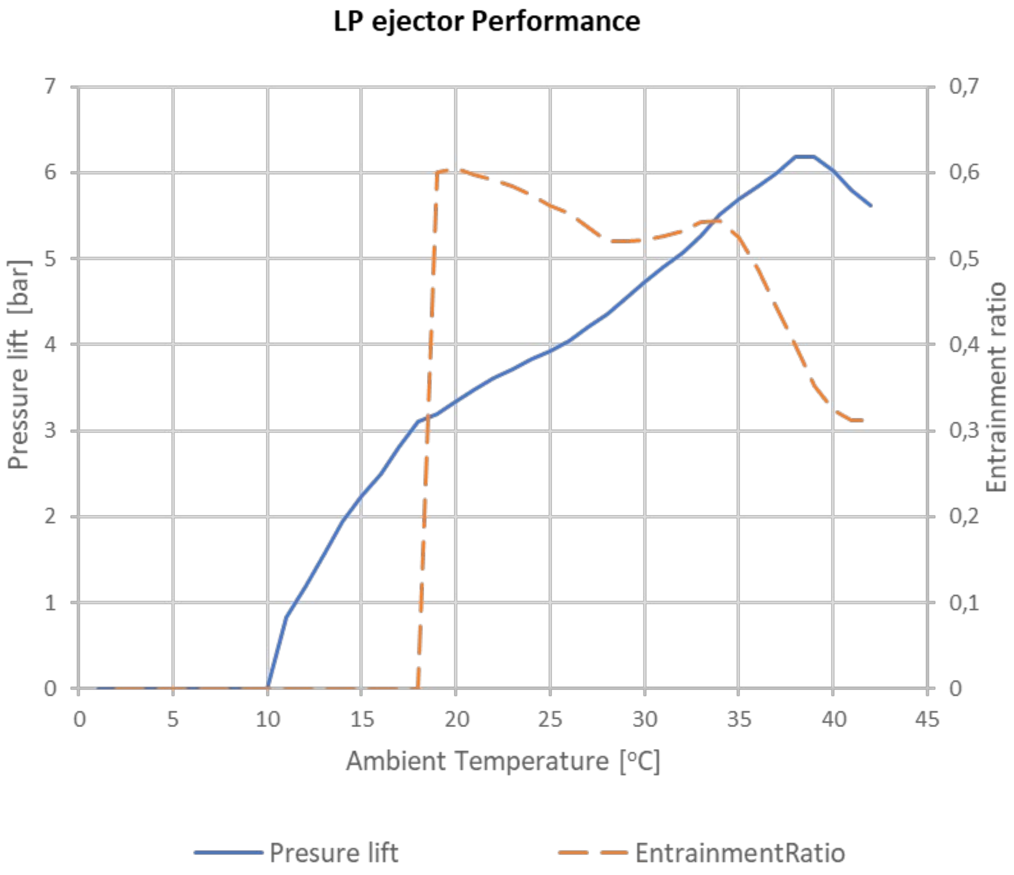


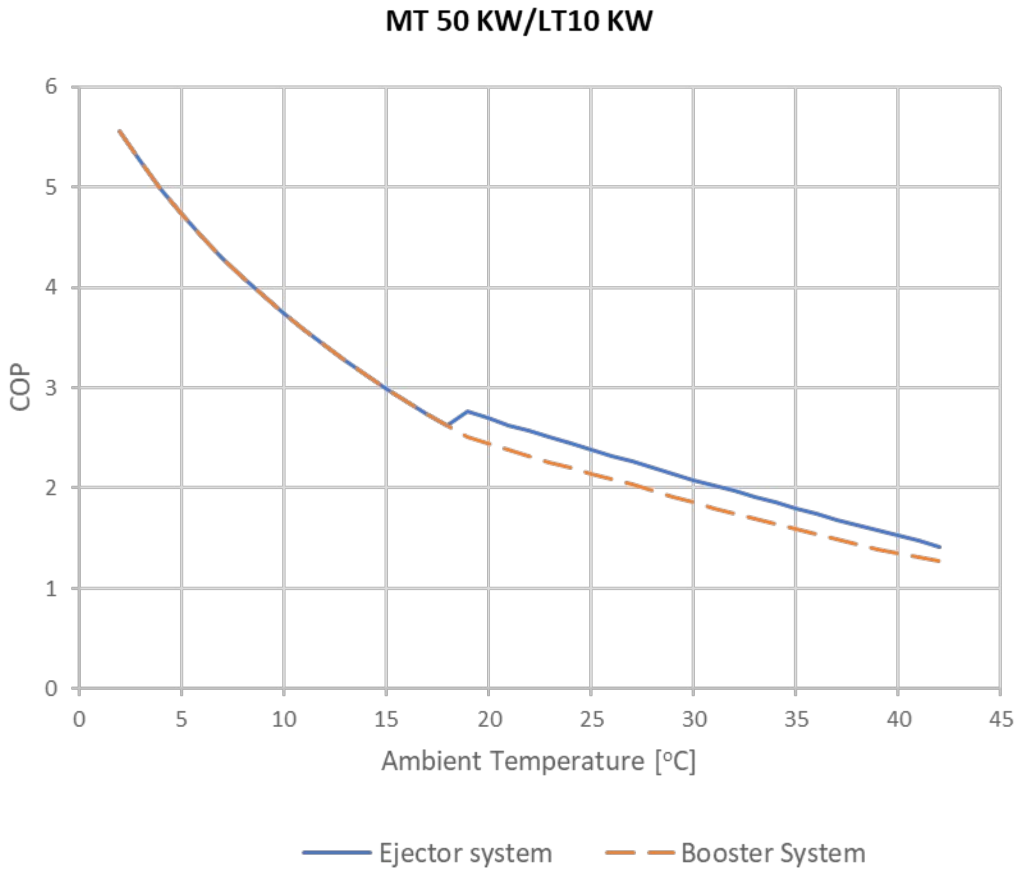
System Analysis

- Gas cooler temperature was calculated based on ambient temperature and curve on right side
- Gas cooler pressure was calculated following the optimal COP line in subcritical and transcritical range, (same as the one implemented in the Danfoss pack controllers)
- Pressure drop in the gas by pass valves was calculated based on the characteristic of the valve (KV value and the discharge coefficient), retrieved form Danfoss data bases
- Pressure loss in the evaporator is considered neglectable
- Performance of the LP ejector was calculated using the model for the Danfoss LP 1935 ejector

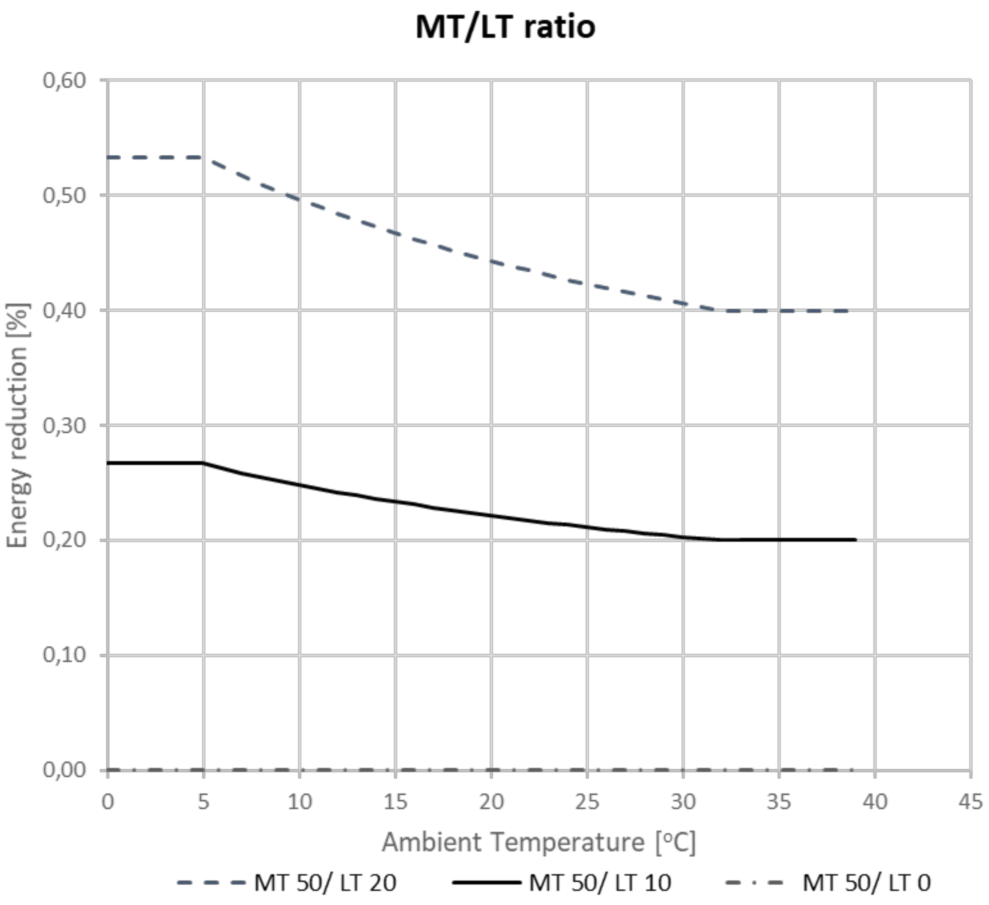


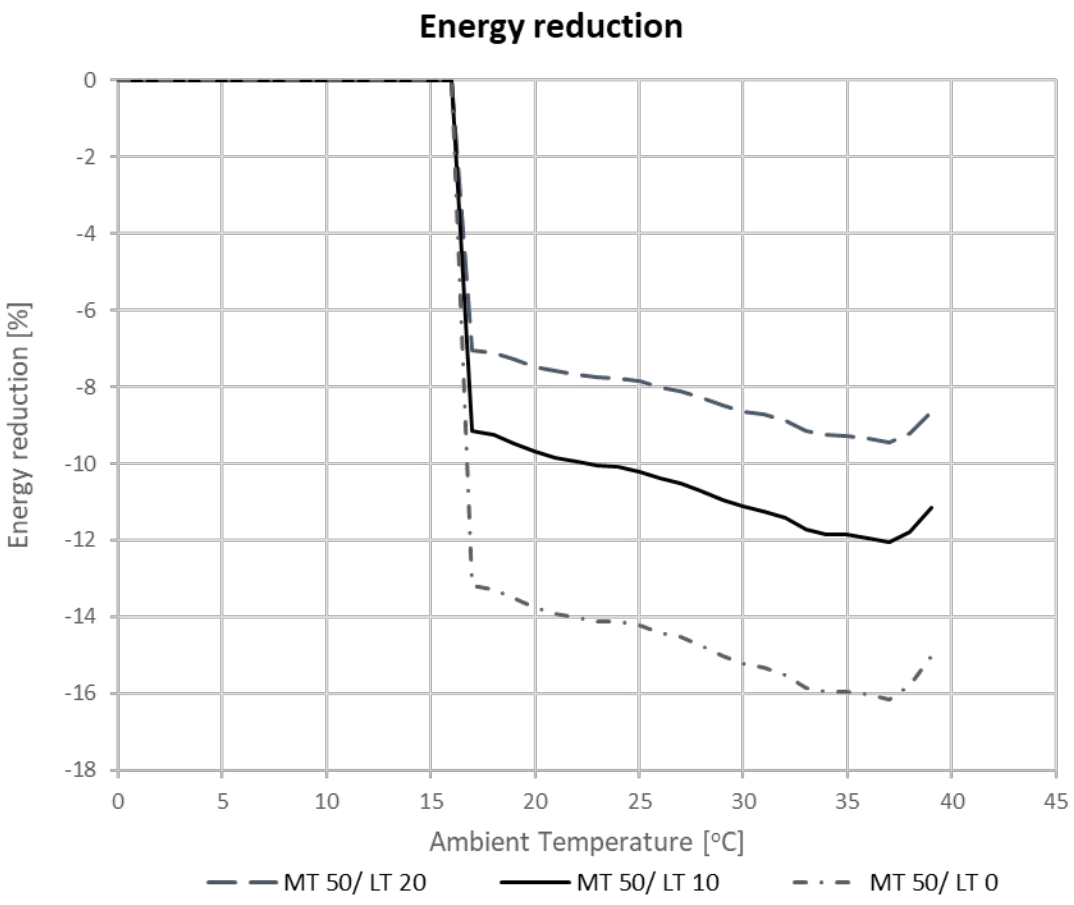
COP improvement / Ambient temperature



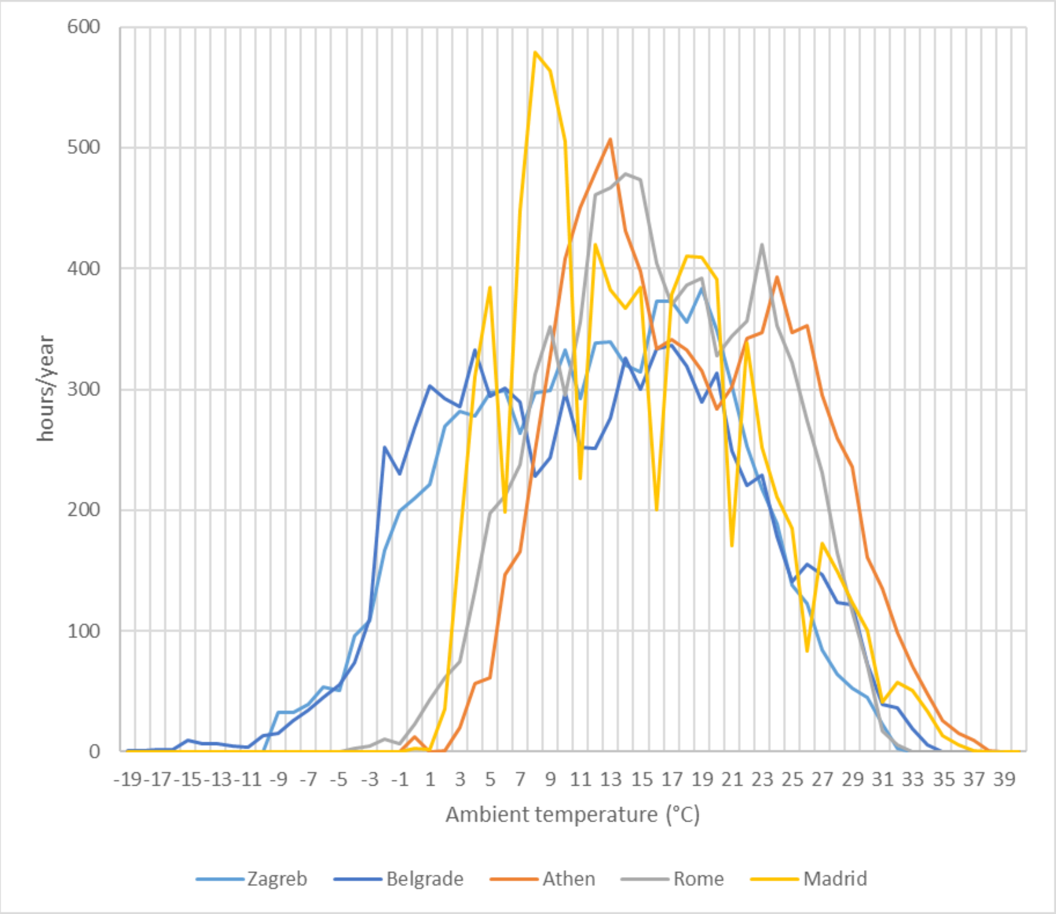


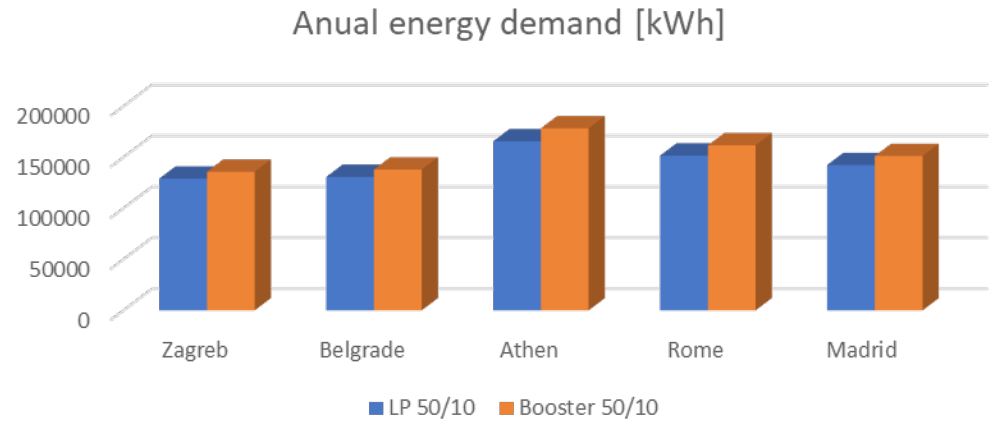
Energy consumption reduction / Amb. temp.

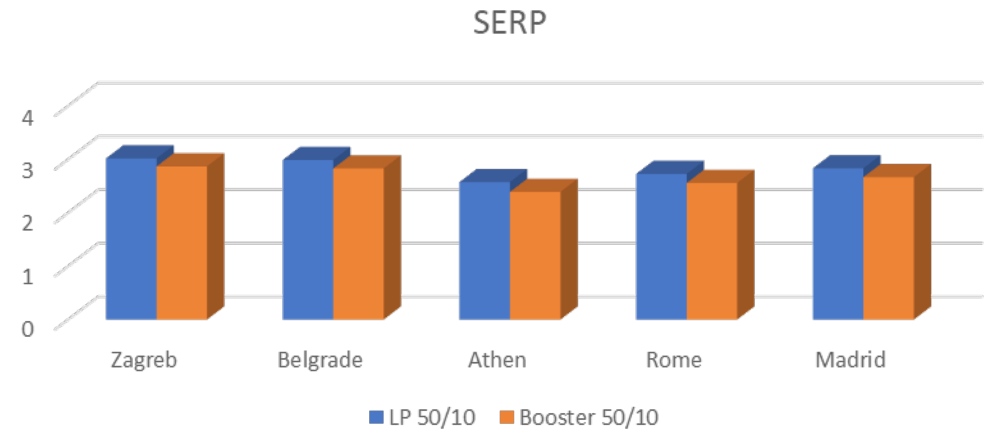




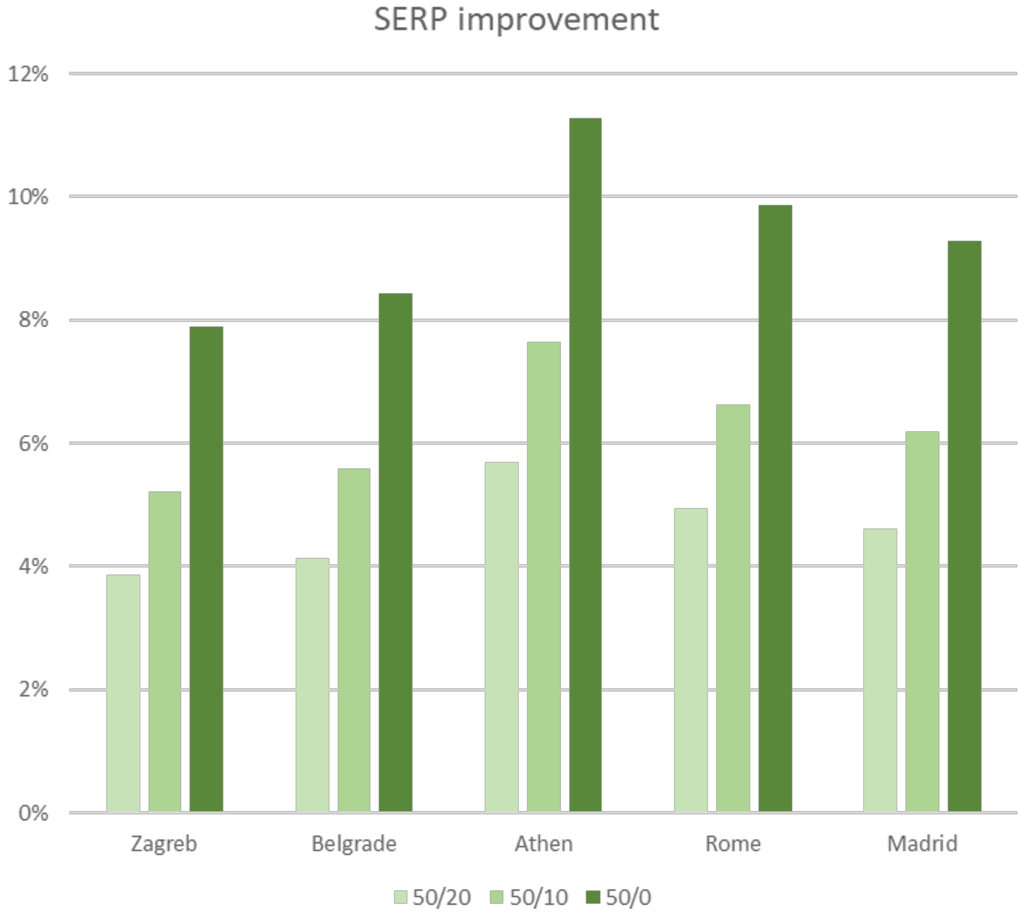
SEPR and Annual energy demand Calculations

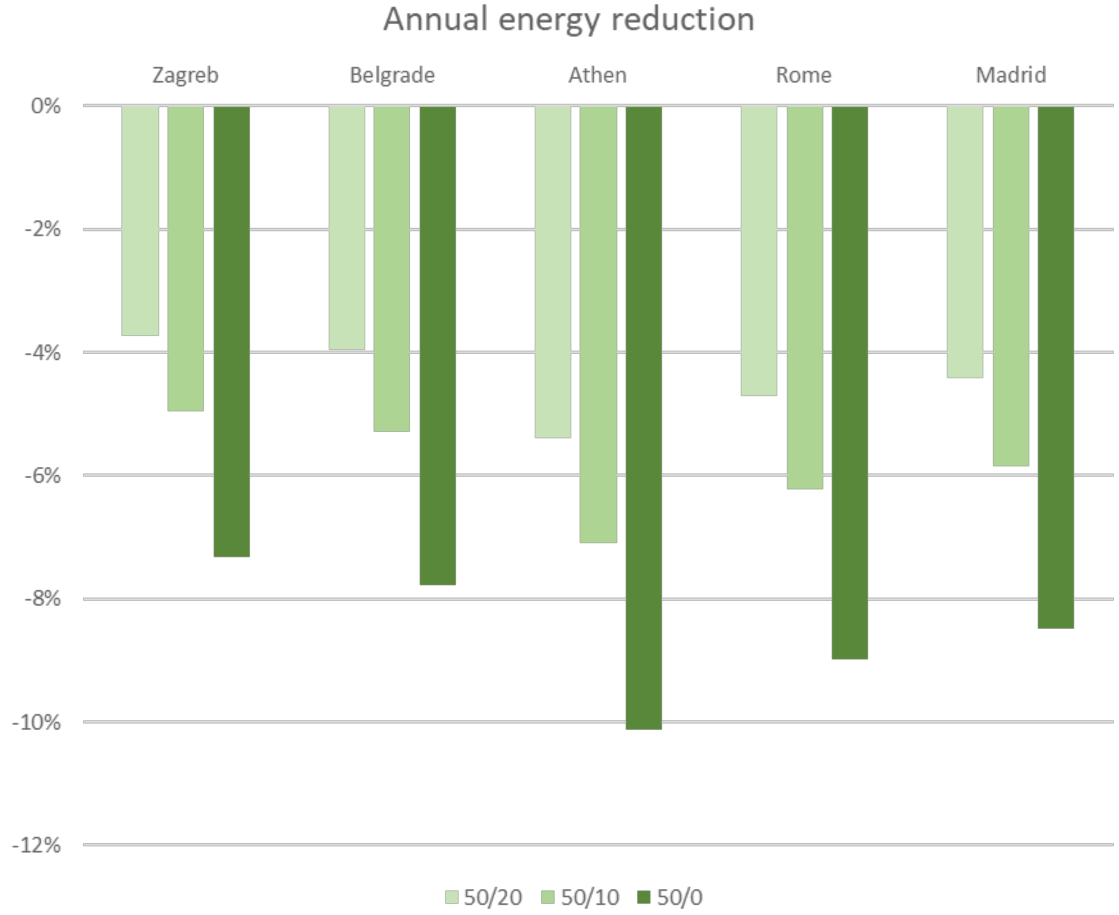




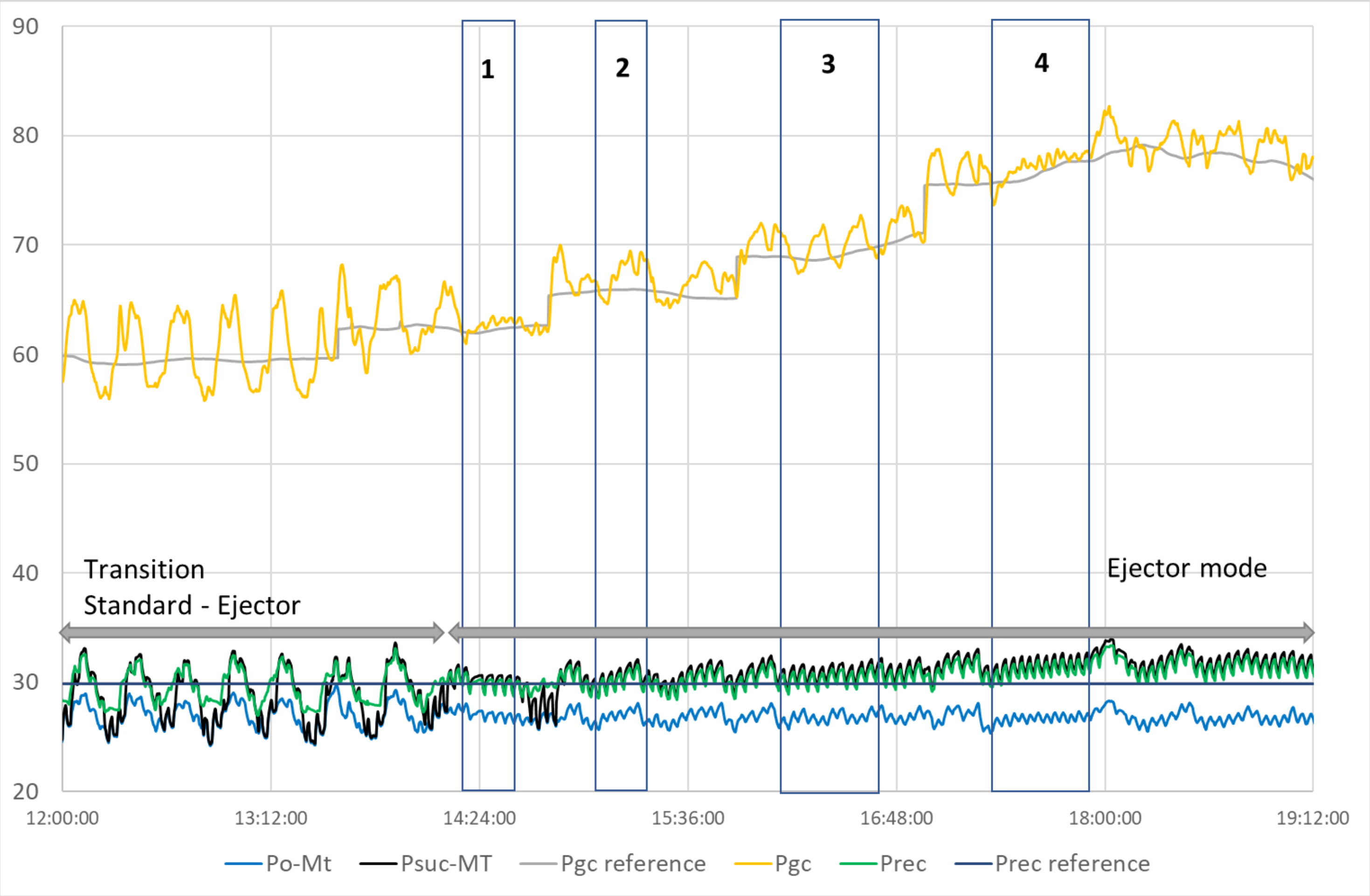


SEPR and Annual energy demand Savings



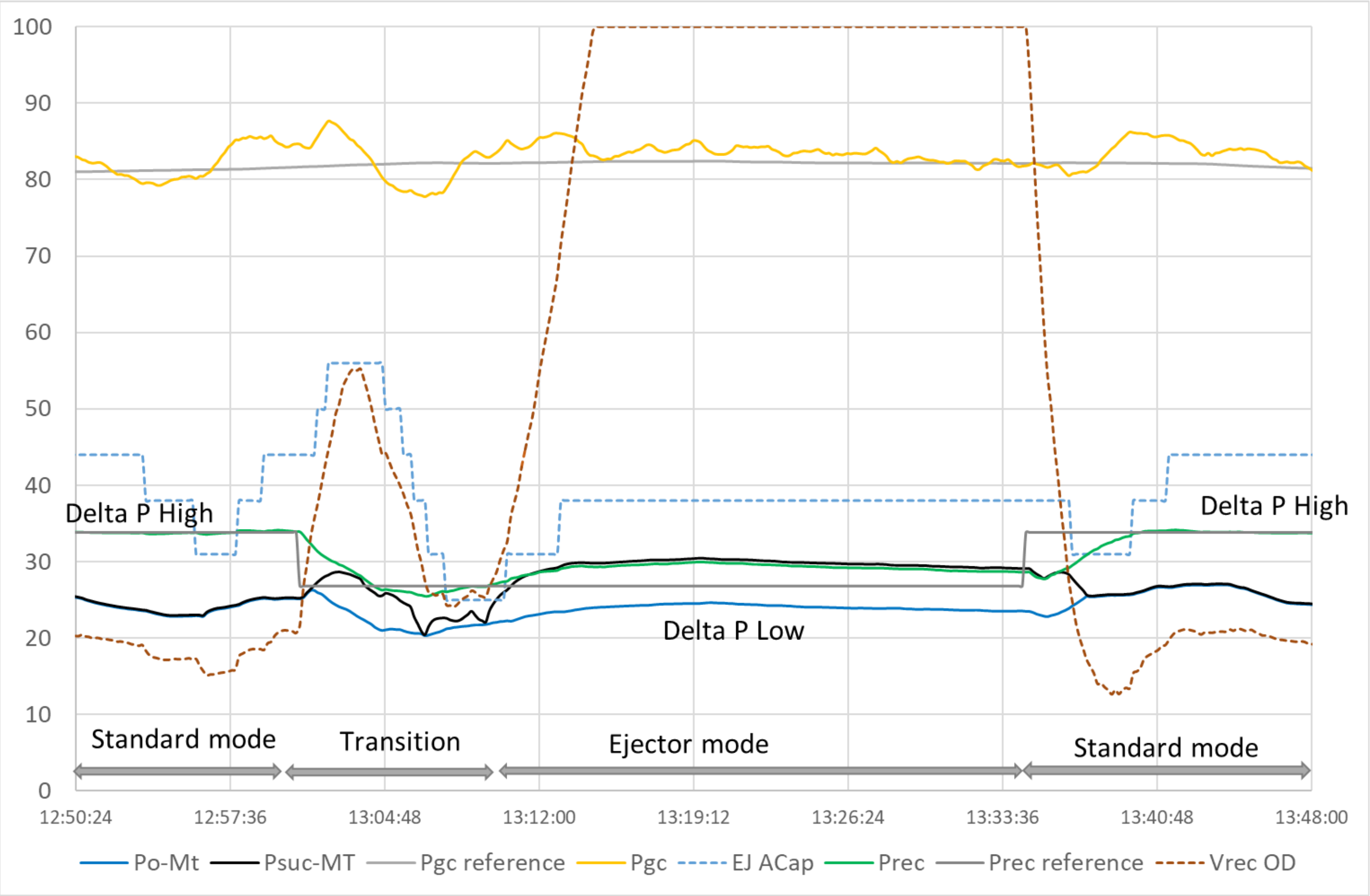


Laboratory test



Period	Po-MT [bar(a)]	Prec [bar(a)]	Pgc [bar(a)]	LP ej lift [bar]
1	27,1	29,9	62,7	**2,8**
2	26,9	30,1	67,1	**3,1**
3	26,7	30,3	70,0	**3,5**
4	26,7	31,0	77,2	**4,4**

Laboratory test



Conclusions

- The integration of ejector in an booster system can improve the performance of the system and result in the reduction of the annual consumption of energy.
- Reduction level depends of the climate as the ejector is operating in ambient temperatures higher than 18°C, and of the load ratio between LT and MT load.
- When the ratio between LT/MT load is small the impact of the ejector in the energy reduction is more pronounced.
- The LP ejector system operates as a standard booster system for temperatures lower than 18 degrees.
- An additional gas by pass valve is required in the system, as well as one additional pressure sensor.
- The receiver pressure control with a constant pressure difference.
- The controllability of the system and the changes of the mode ware tested in the laboratory. When system moves from standard mode to ejector mode it takes around 10 minutes to stabilize while when it changes from ejector to standard mode the transition happens immediately.