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EXPERIENCES FROM SUPERCRITICAL CO_2 APPLICATIONS IN REFRIGERATION AND A/C SYSTEMS

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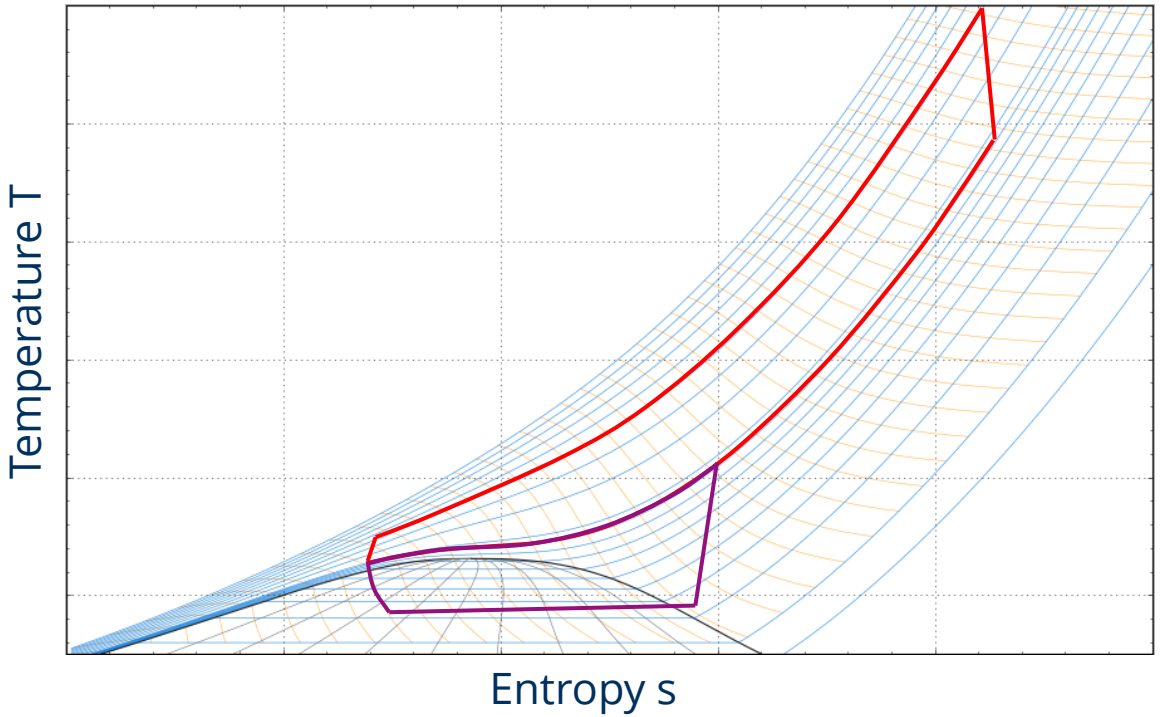
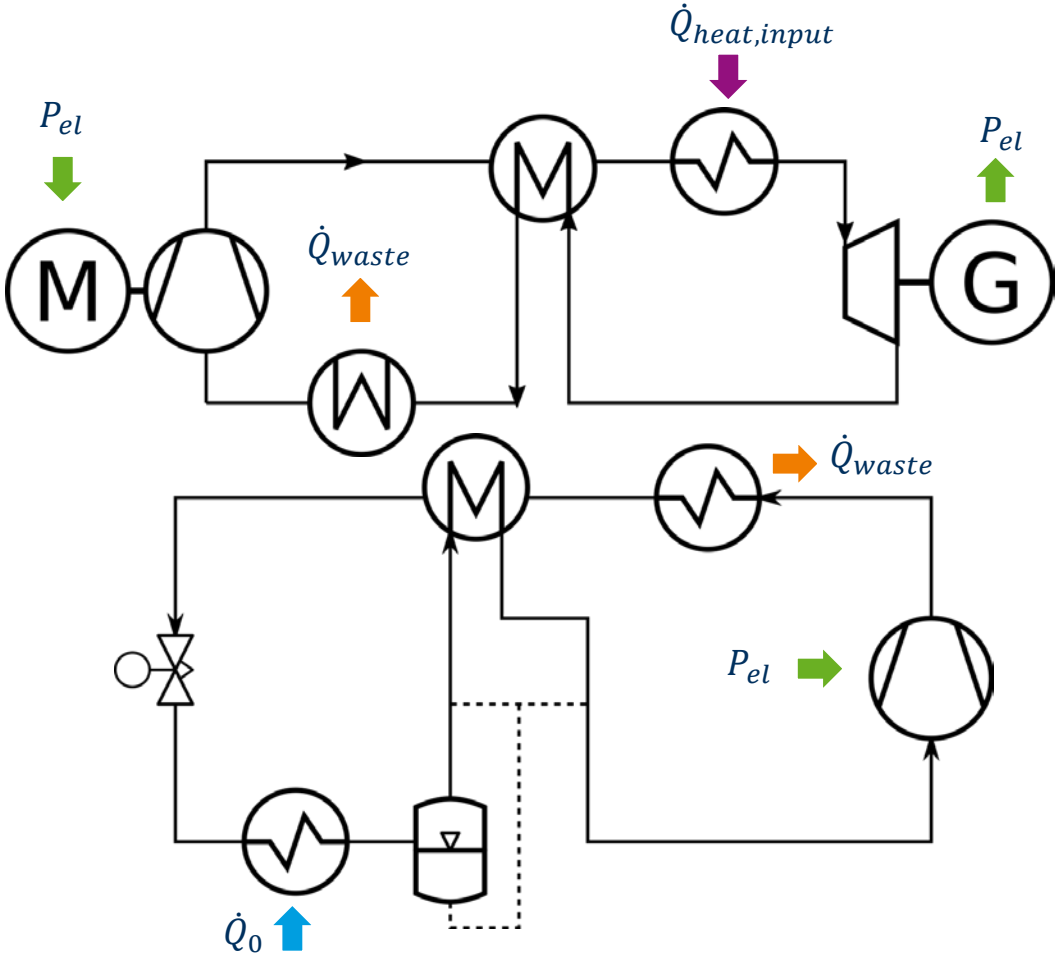
sCO_2 power cycles and cooling cycles

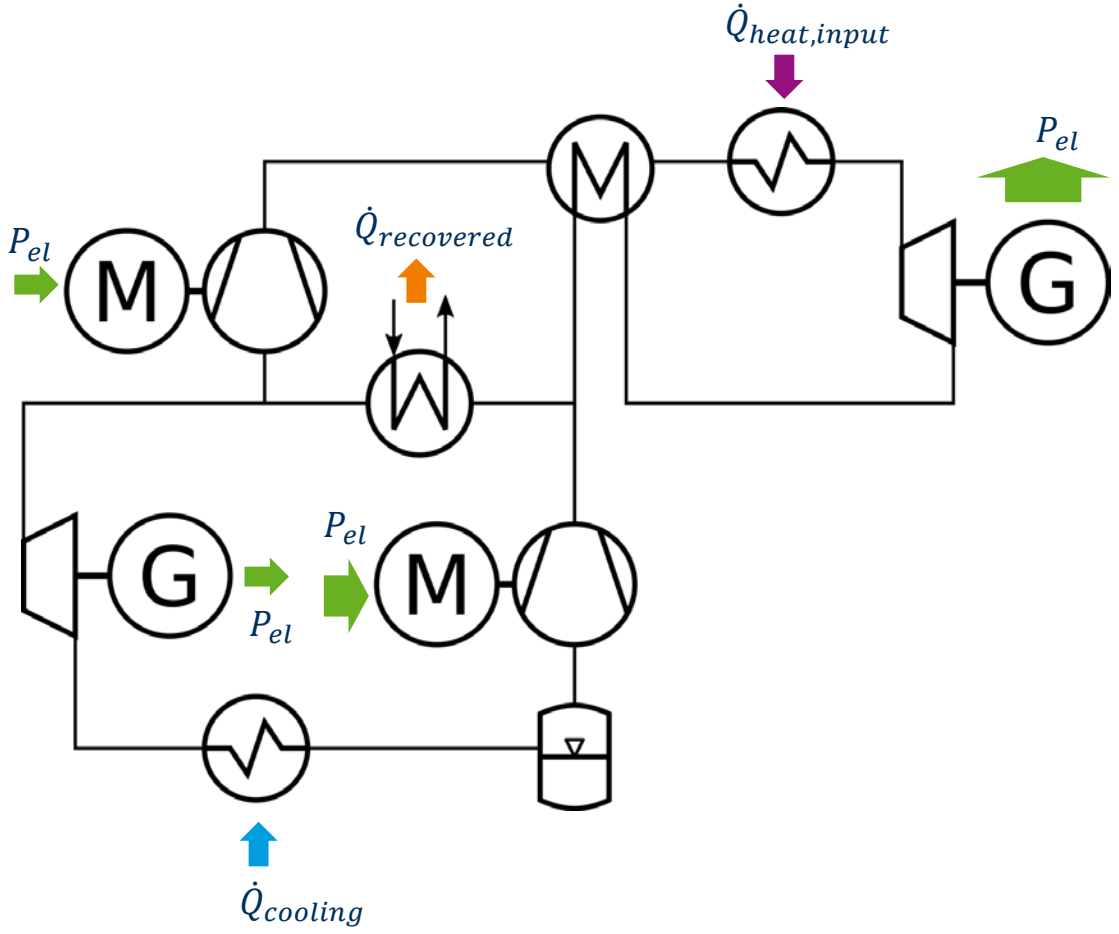
- Research and development for sCO_2 power cycles
- Research and commercial application of transcritical CO_2 cooling cycles





Combination of power generation and cooling cycle

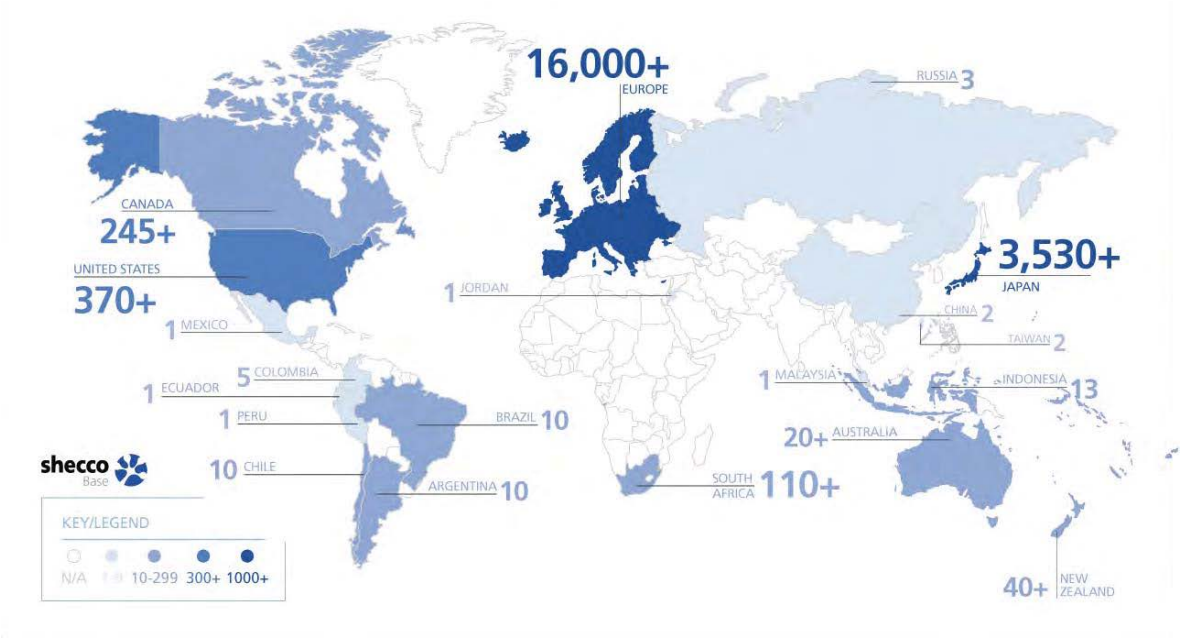
- Integration of cooling, heating and power generation in one system („tri-generation“)
- Less heat exchangers cost
- Use „Waste Heat“, e.g. for district heating
- Joint development of machinery



Background: Spreading of CO_2 refrigeration systems

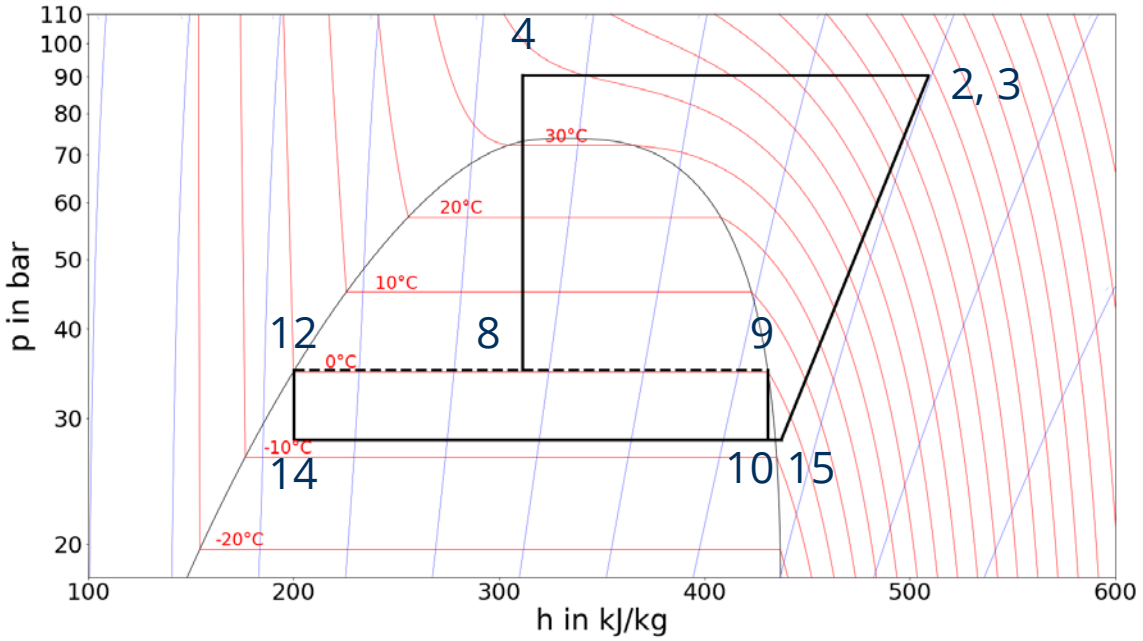
- From ~100 transcritical operating CO2 systems to >20.000 systems in 15 years
- Growing importance in Europe
- Thermal capacity from kW to MW

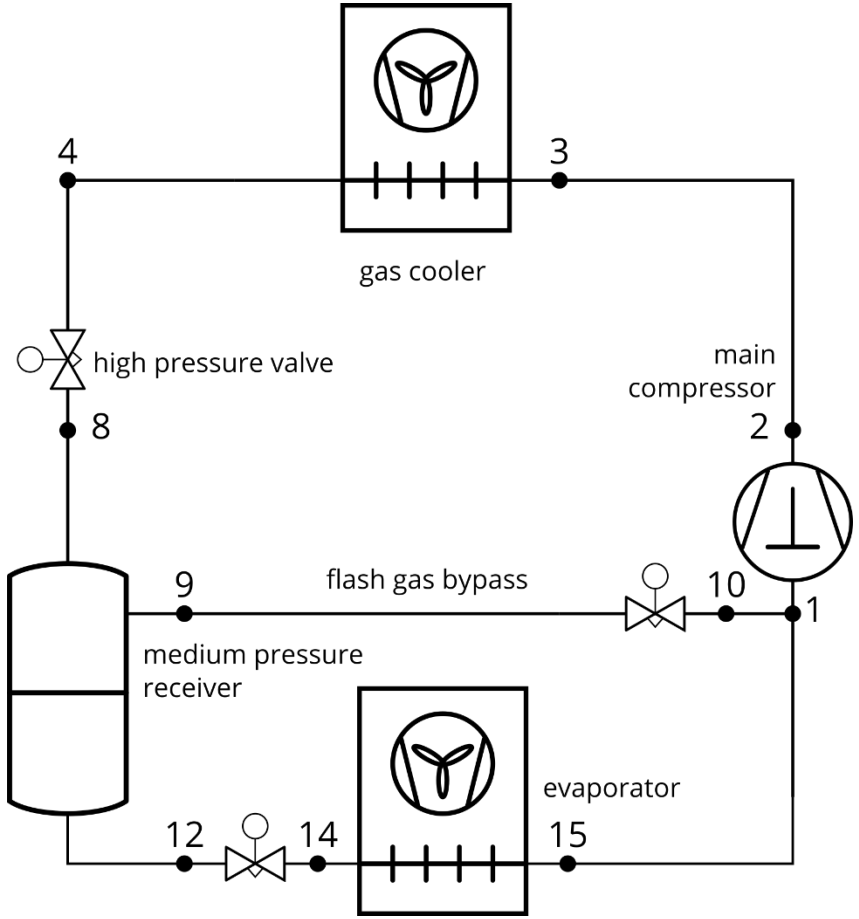
Source: K. Zolcer Skacanova, A. De Ona (Shecco): Market & Technology trends for CO_2 and Ammonia in commercial and industrial refrigeration, 2019



Flash gas bypass system as basic system

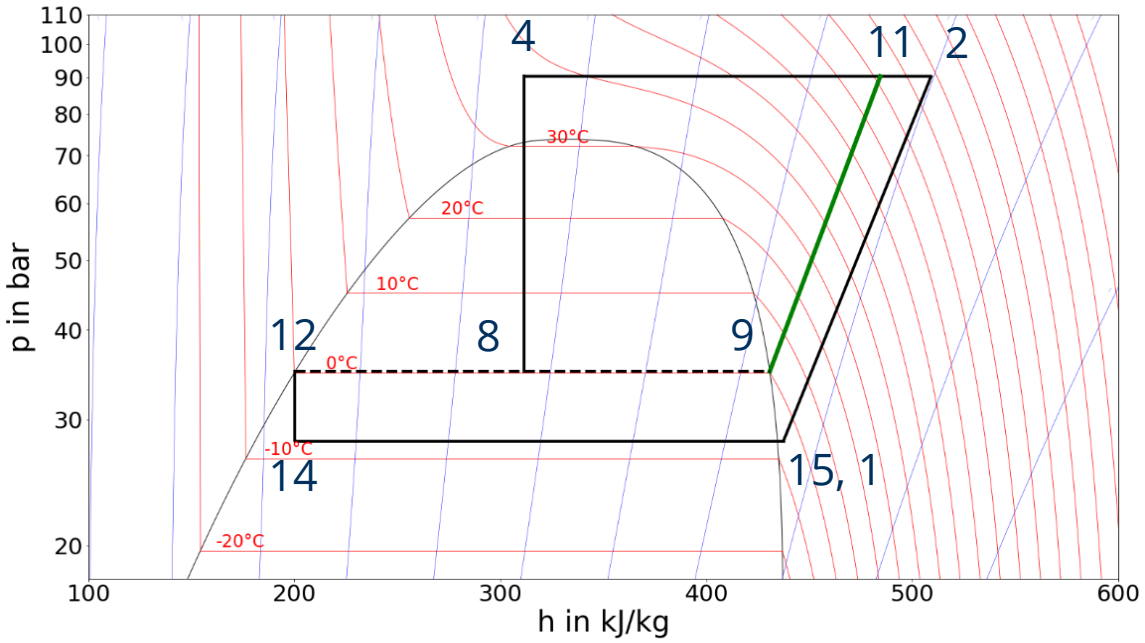
- Basic cycle including **gas cooler, high pressure valve, intermediate pressure receiver, flash gas valve** and **evaporator**

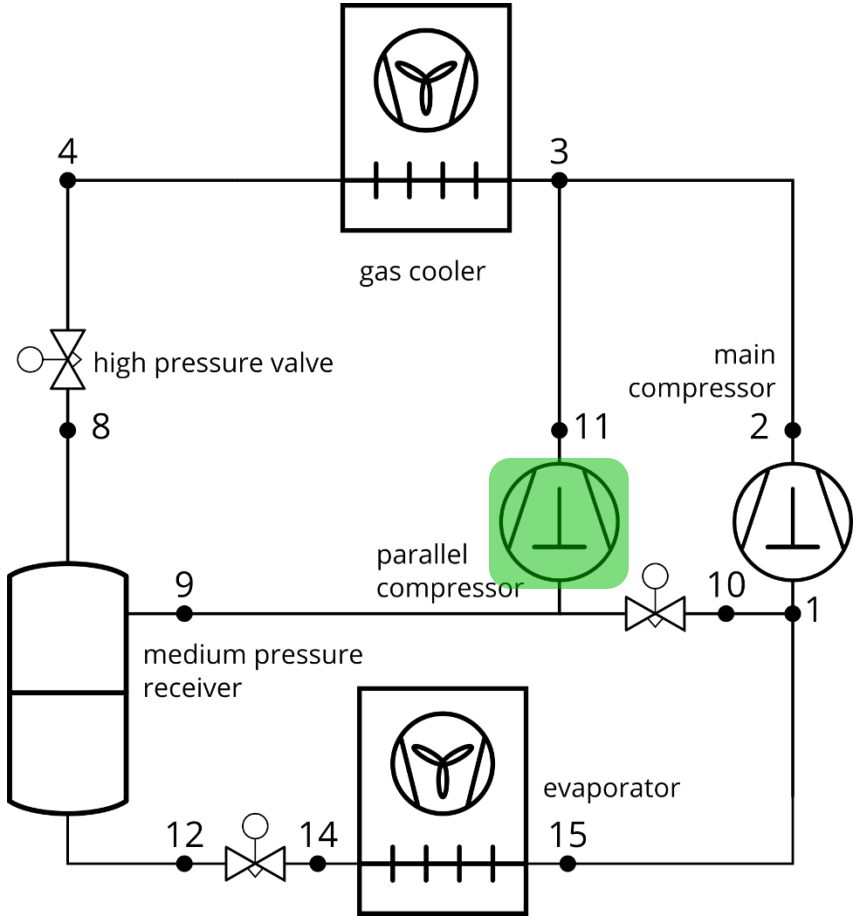




Efficiency enhanced CO_2 cycles: parallel compression

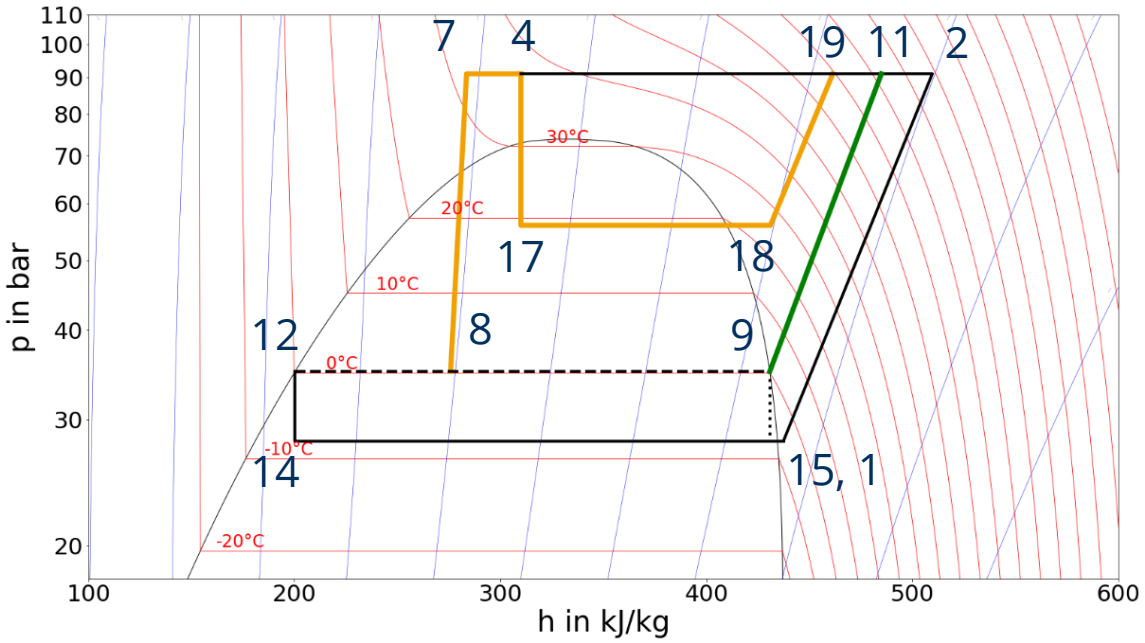
- **Parallel compression**

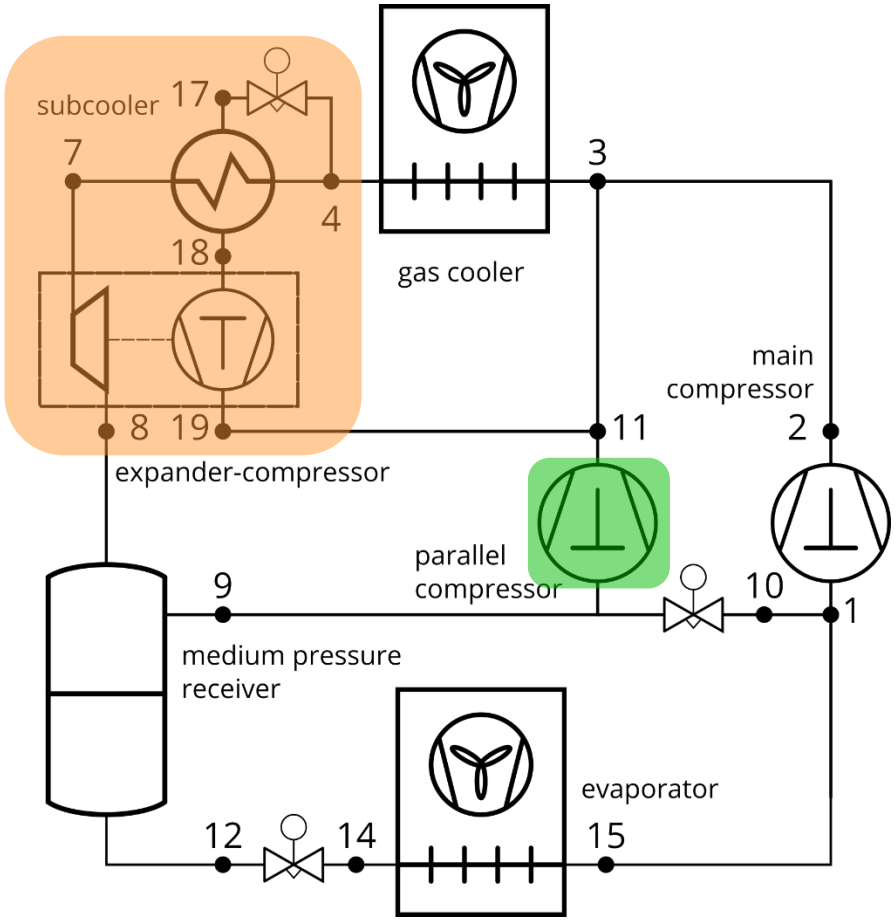




Efficiency enhanced CO_2 cycles: internal subcooling

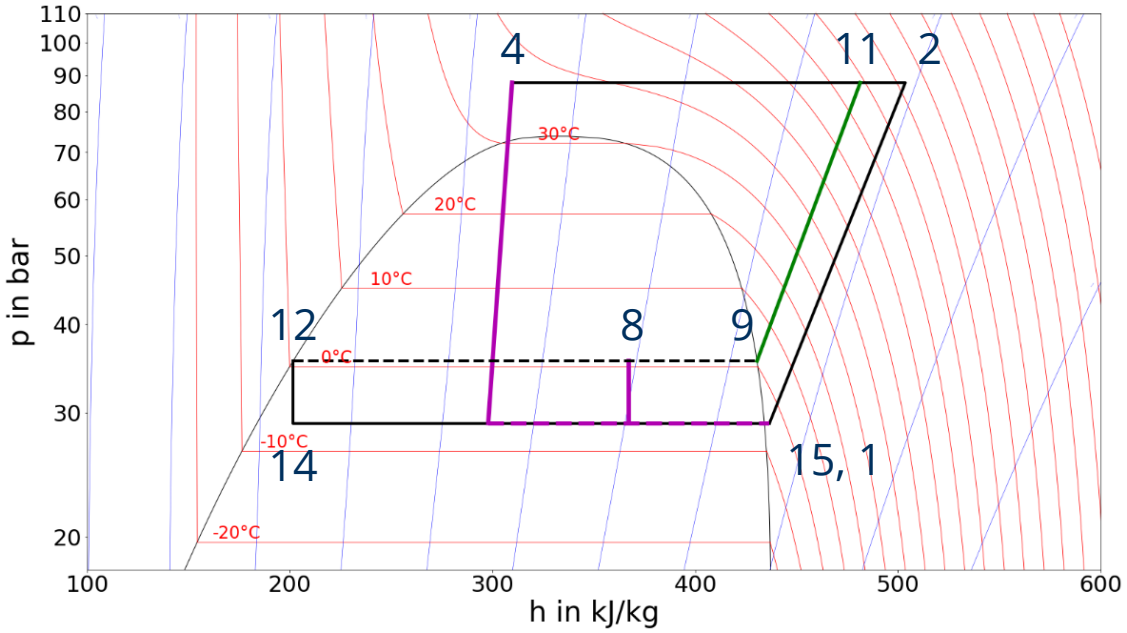
- Parallel compression
- **Expander (expansion compression unit, ECU) and economiser cycle**

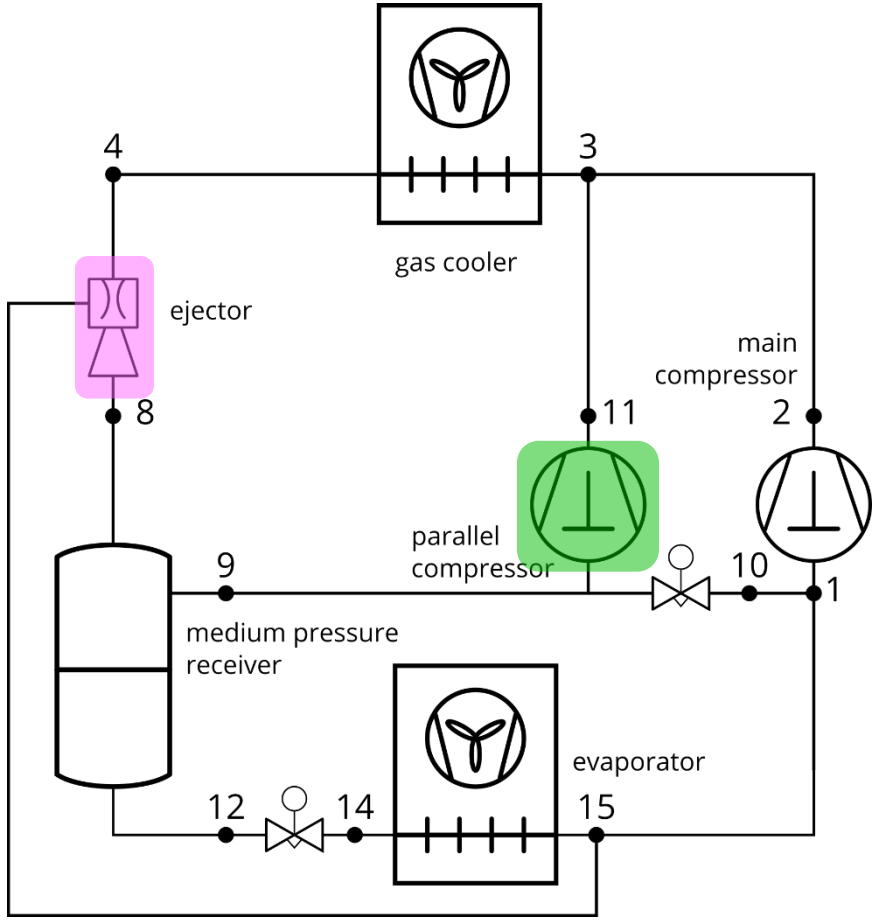




Efficiency enhanced CO_2 cycles: ejectors

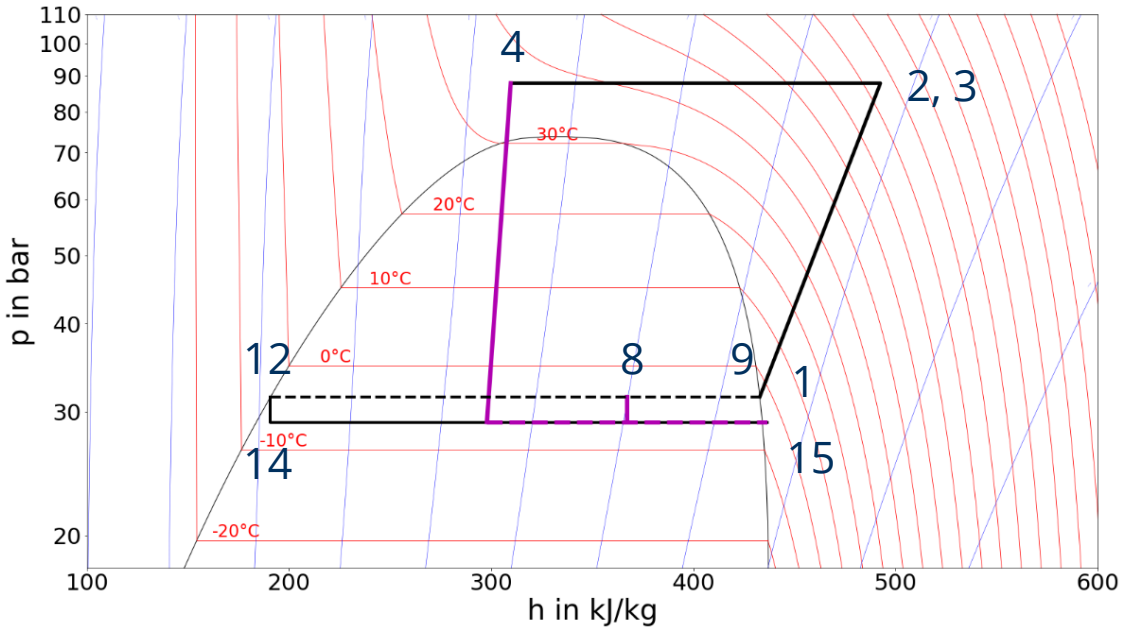
- Parallel compression
- **Ejectors**
  - ➢ **High lift ejector**

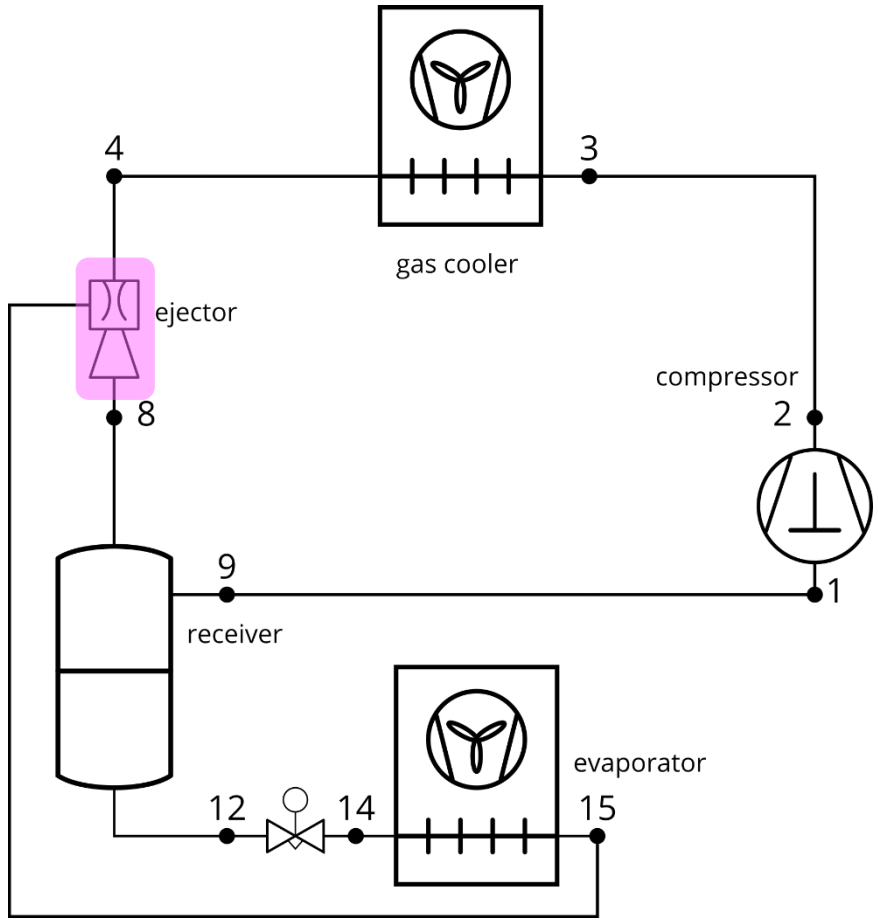




Efficiency enhanced CO_2 cycles: ejectors

- **Ejectors**
  - **High lift ejector**
  - **Low lift ejector**





Investigated CO_2 refrigeration system

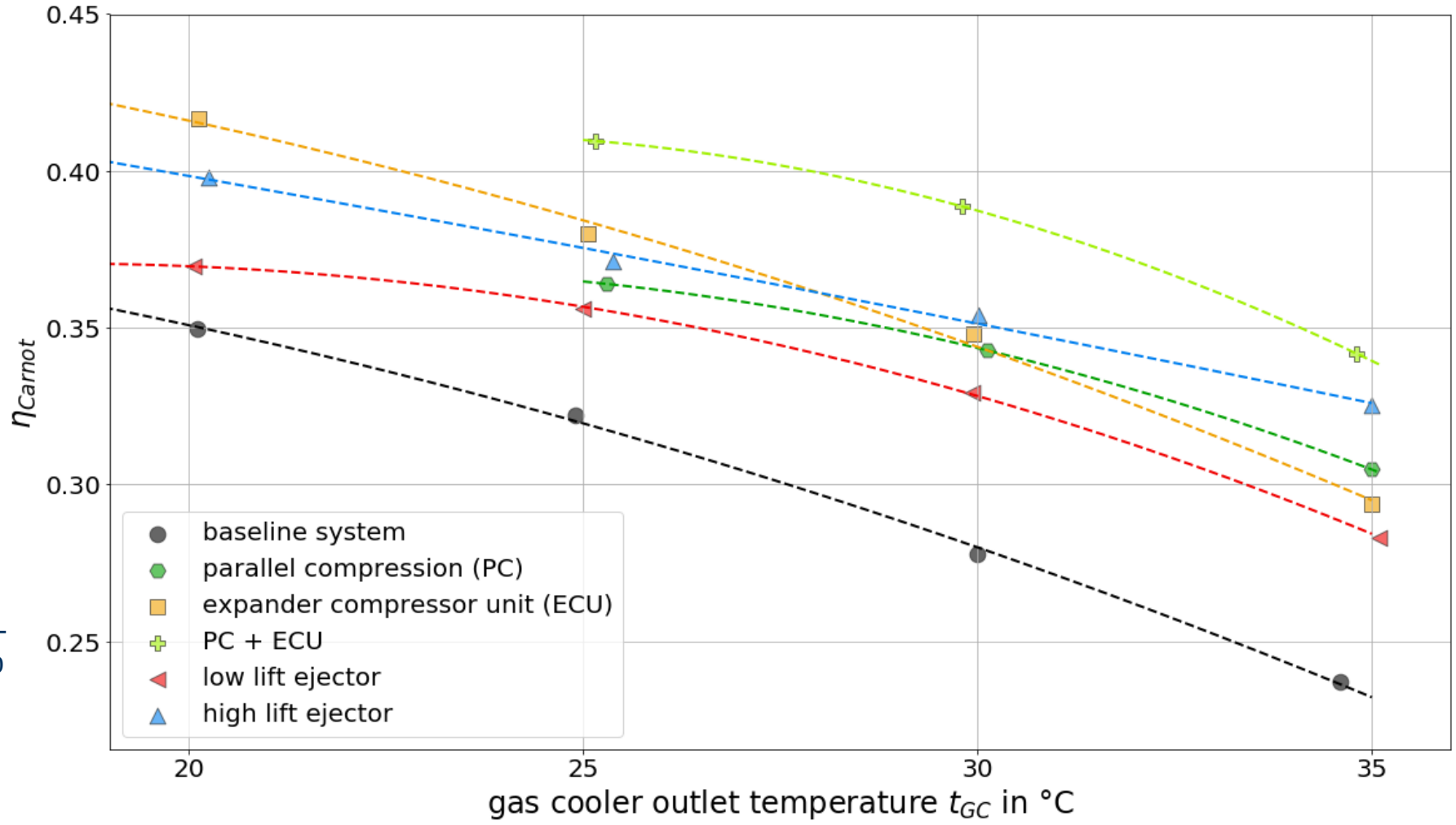
- Comparison of efficiency enhancing measures, including:
  - Parallel compression
  - Ejectors
  - Expansion-compression-unit (ECU) and internal subcooling
  - External subcooling
- By a specially adopted laboratory CO_2 system

Measured results: Carnot efficiency

$$\eta_{Carnot} = \frac{COP_{ref}}{COP_{Carnot}}$$

$$COP_{ref} = \frac{\dot{Q}_{cooling}}{P_{el}}$$

$$COP_{Carnot} = \frac{T_0}{T_{GC} - T_0}$$



Summary and next steps

- Experiences with transcritically operating CO_2 systems
- Various CO_2 cooling **cycle enhancements** for efficiency increase
- Measurements of efficiency of different CO_2 cooling systems at varying operating conditions
- All investigated enhanced cycles show increased efficiency
- Optimized **system control** necessary for maximum efficiency
- **Common** development and application of **components** advantageous

Thank you for your attention!

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