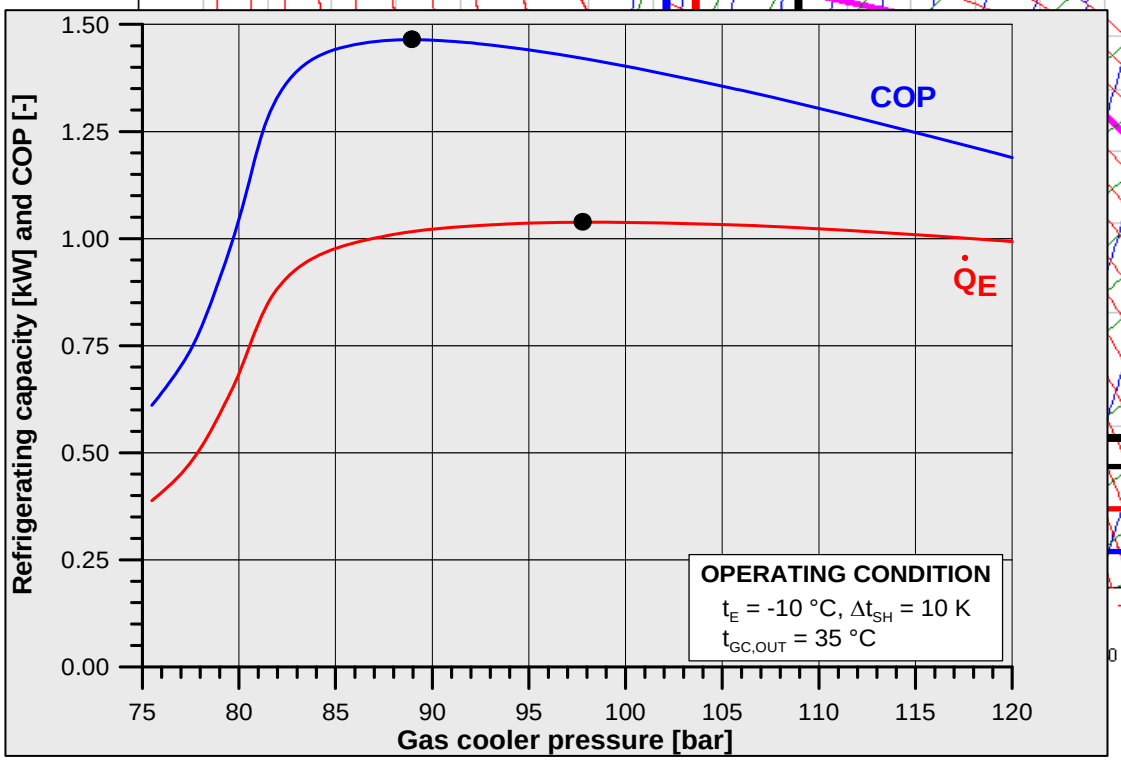
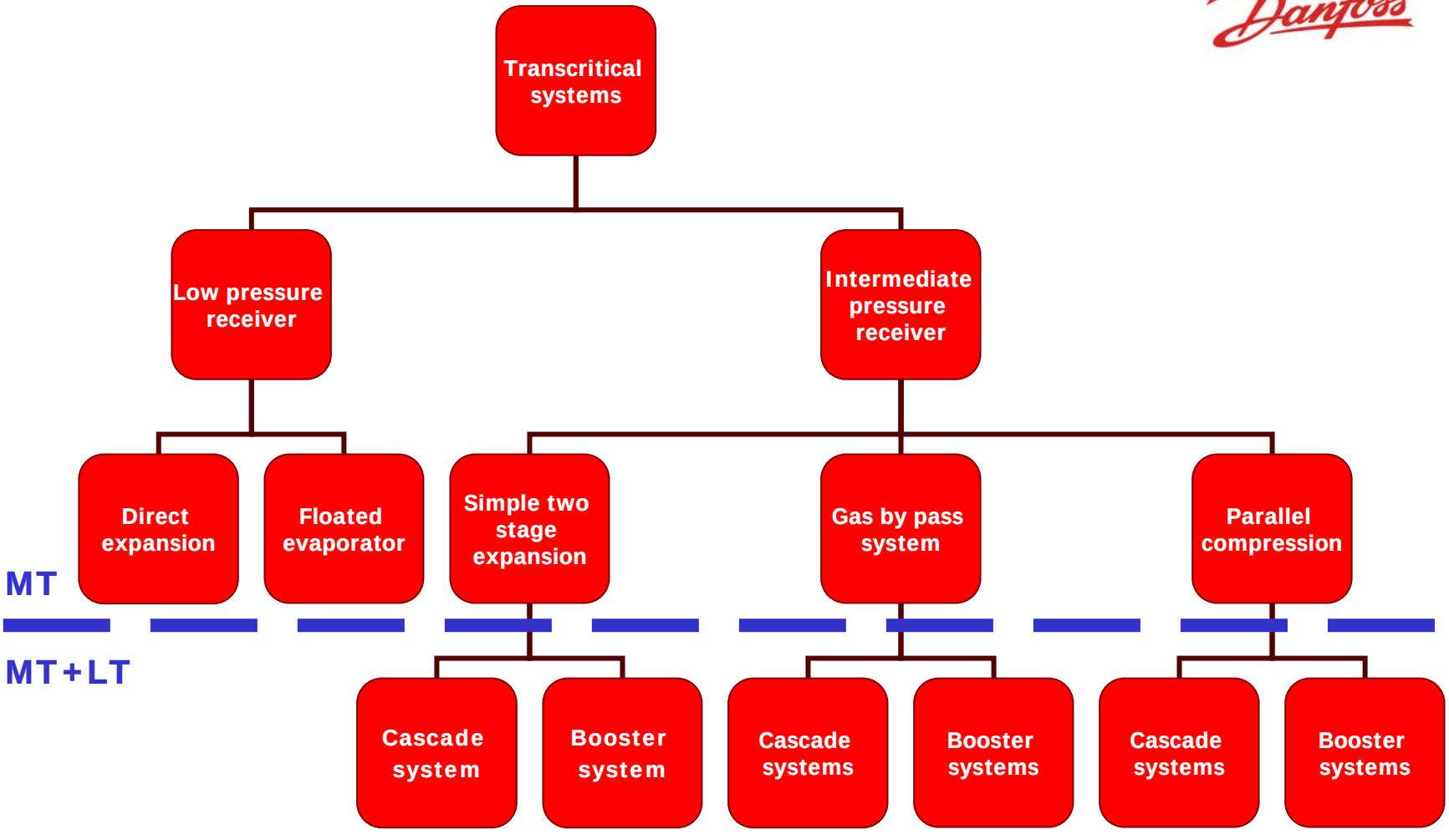
Transcritical CO2 systems

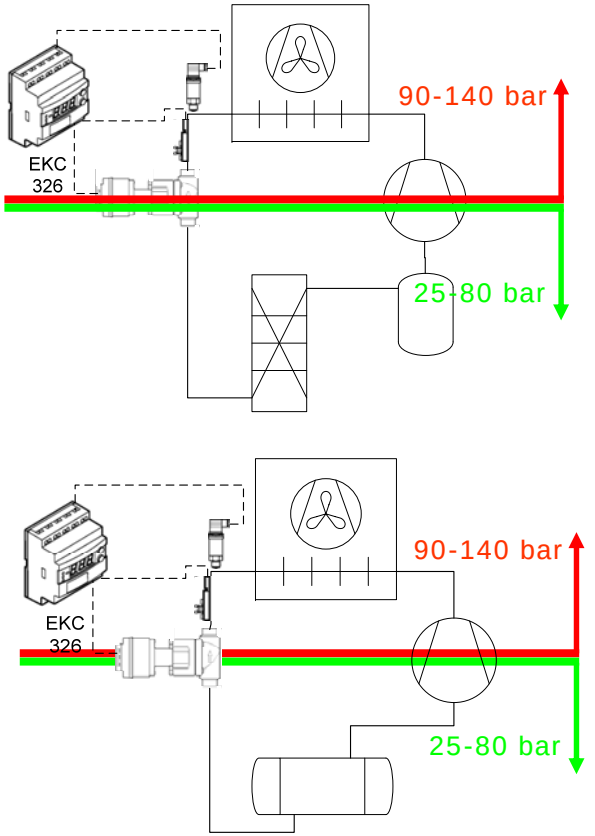
Transcritical systems

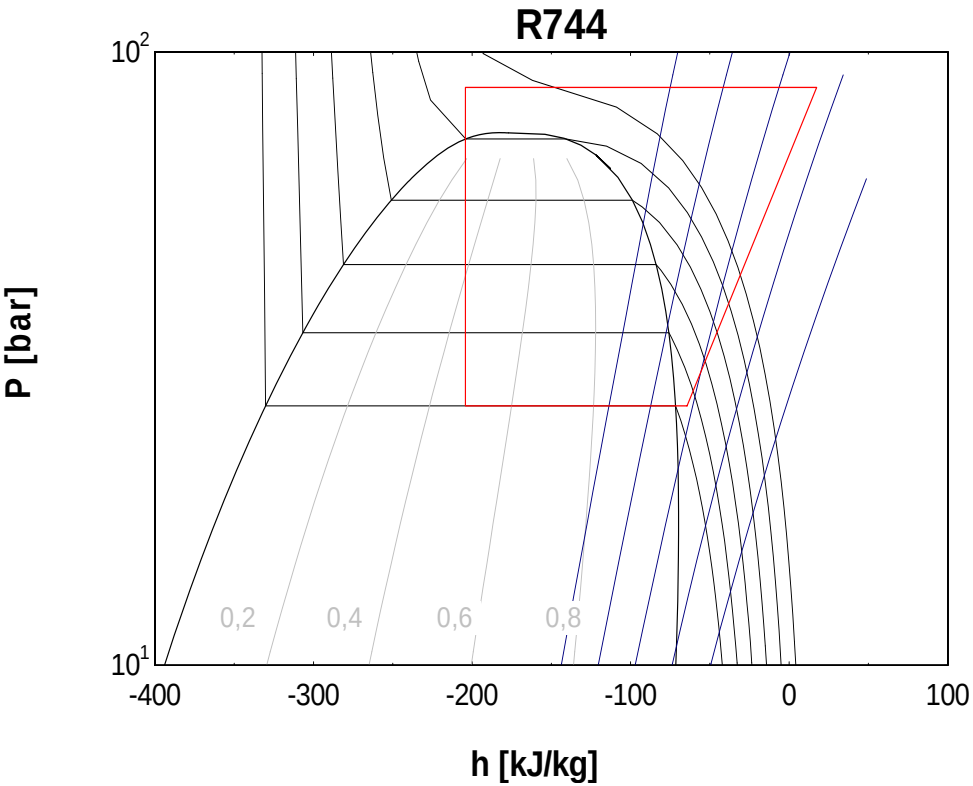
Optimal High Pressure



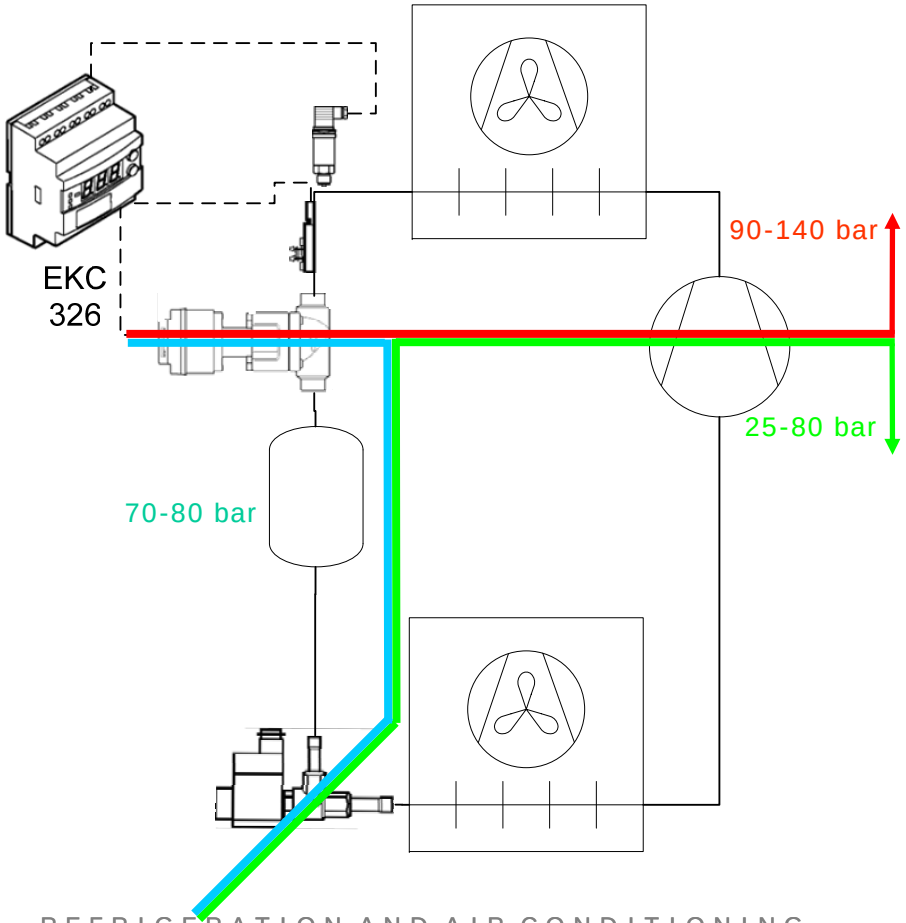

Transcritical systems
Low pressure receiver
Intermediate pressure receiver
Direct expansion
Floated evaporator
Simple two stage expansion
Gas by pass system
Parallel compression
MT
MT+LT
Cascade system
Booster system
Cascade systems
Booster systems
Cascade systems
Booster systems

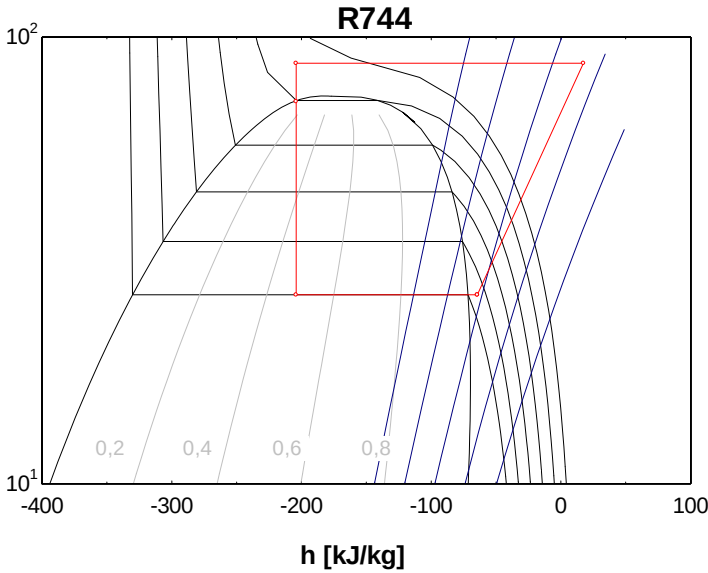
Low pressure receiver / single stage expansion



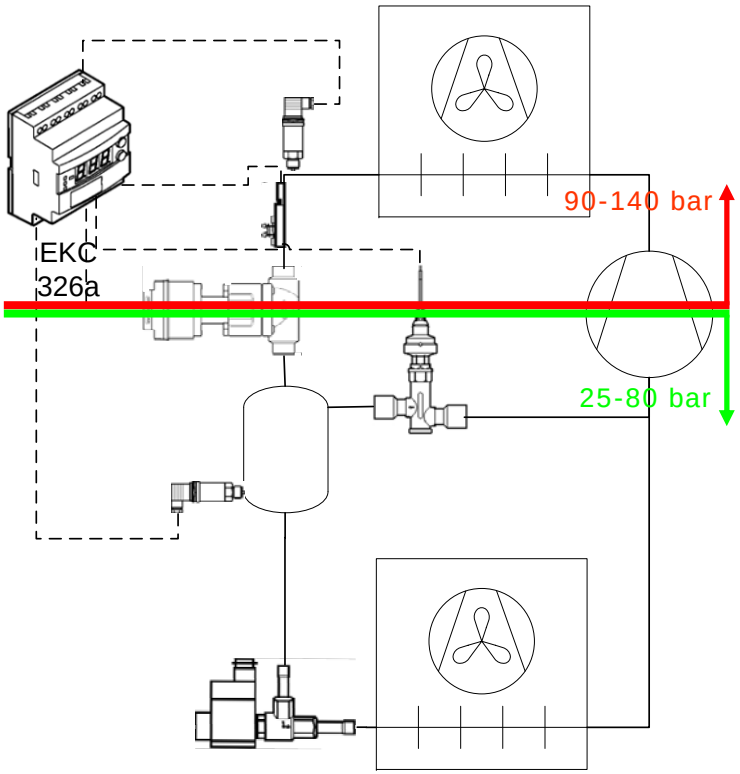


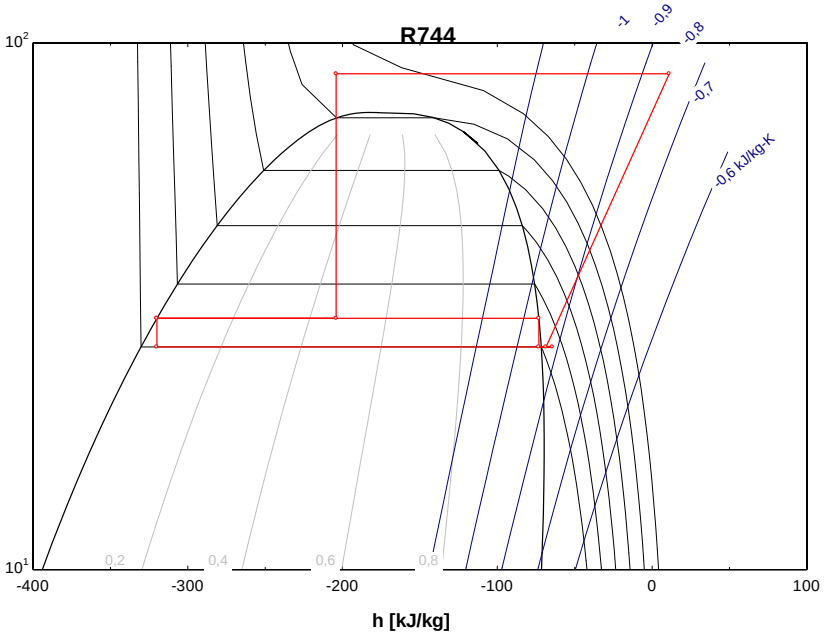
Simple two stage expansion



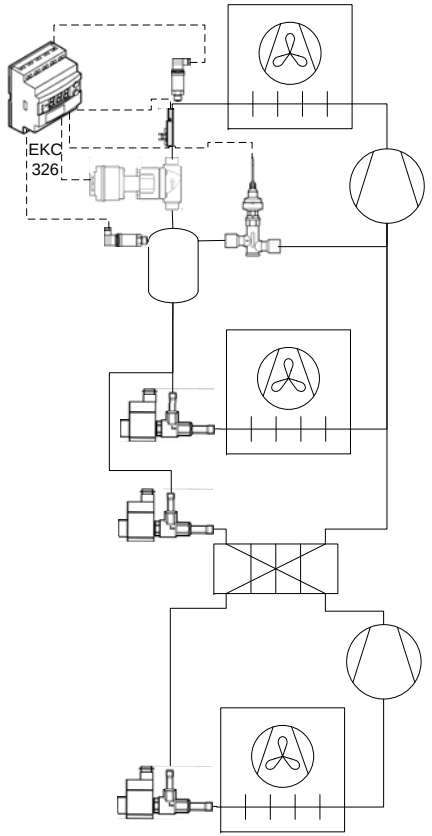


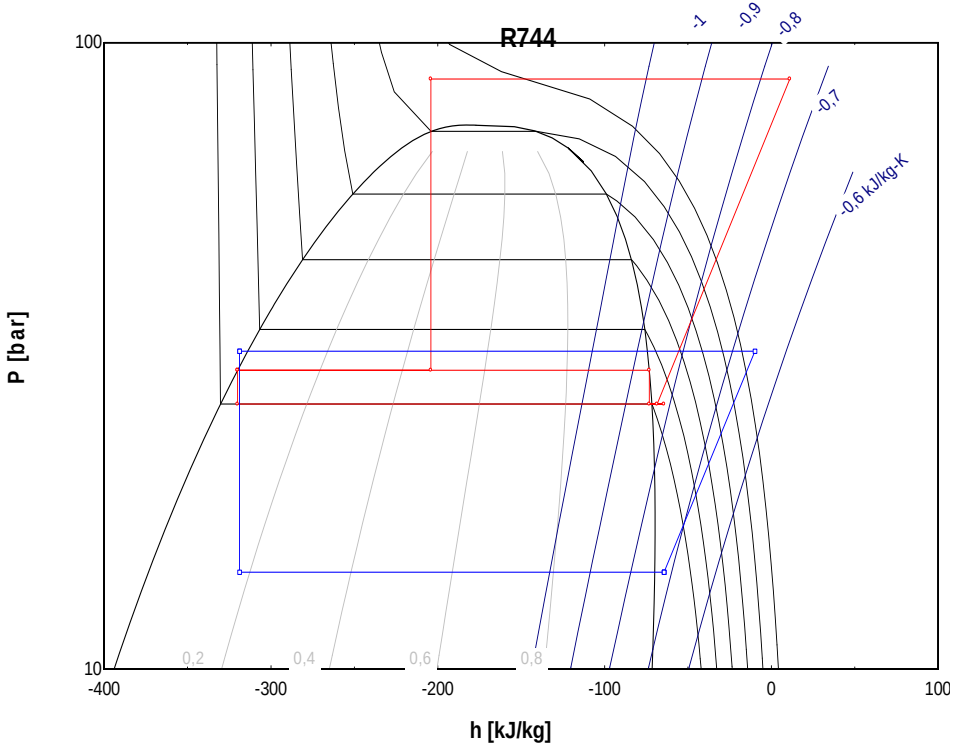
Gas by-pass system



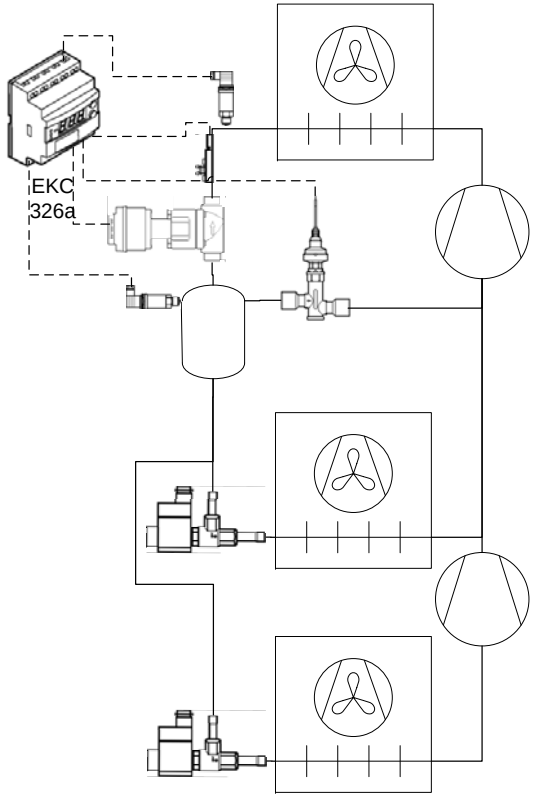


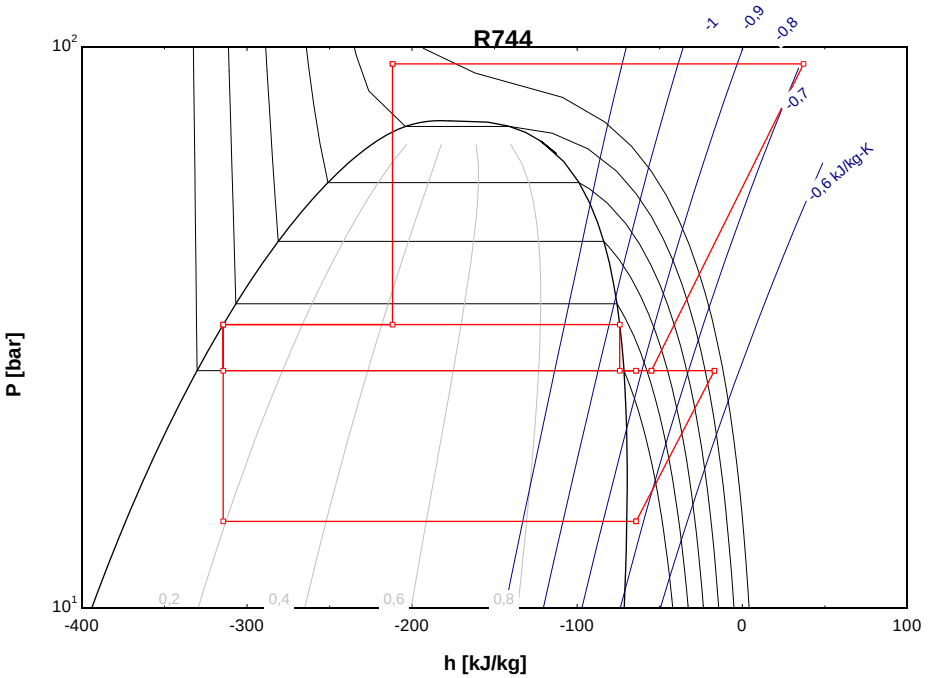
Cascade systems: Gas by pass





Booster system: Gas by-pass





Heat reclaim transcritical systems

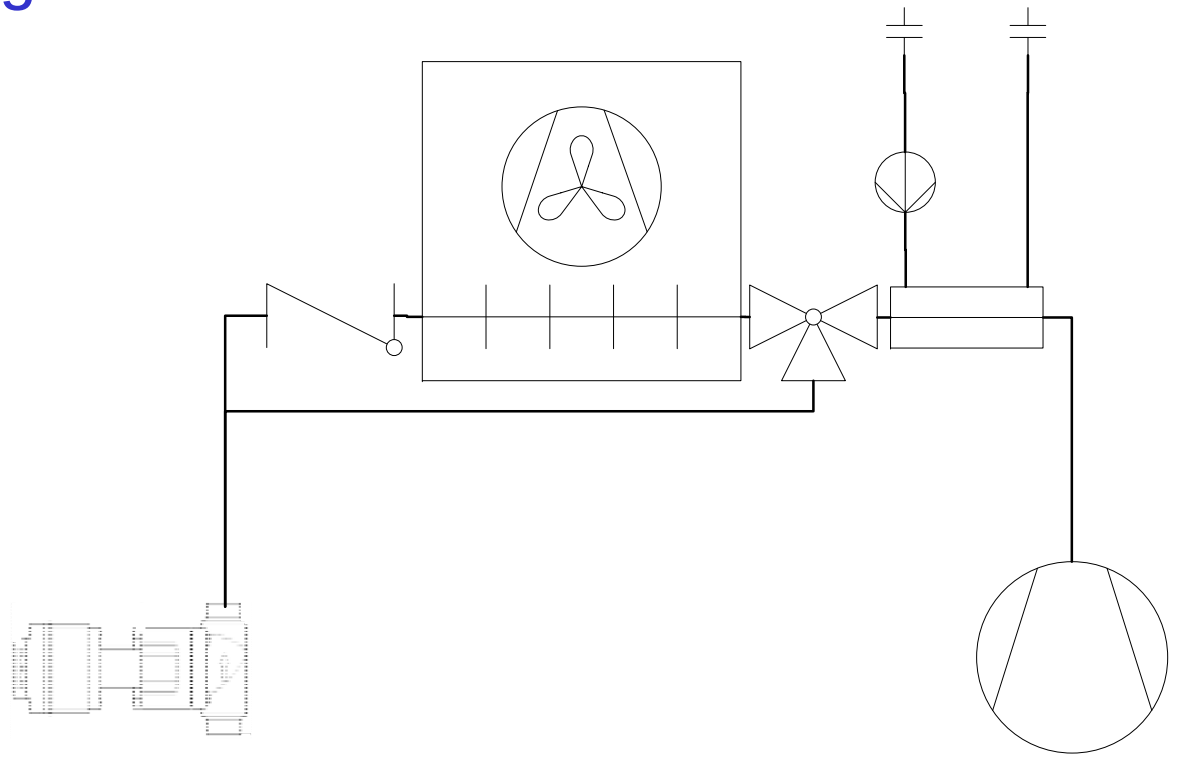
Basic idea

- Reclaim the heat needed at the needed temperatures as efficient as possible

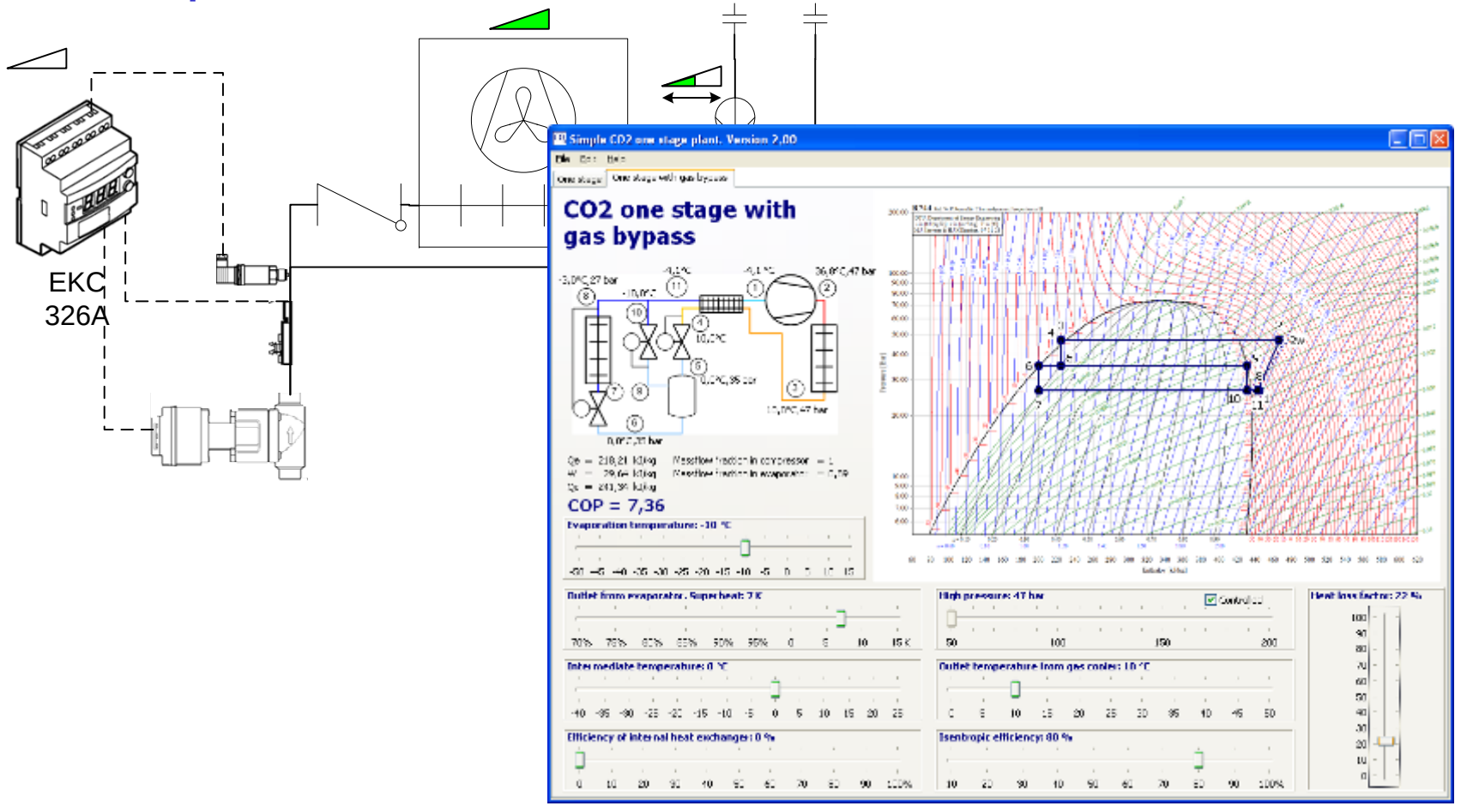
Example

- Heat water from 15 to 55 ºC with the highest possible effiency
- ~0 ºC Ambient temperature

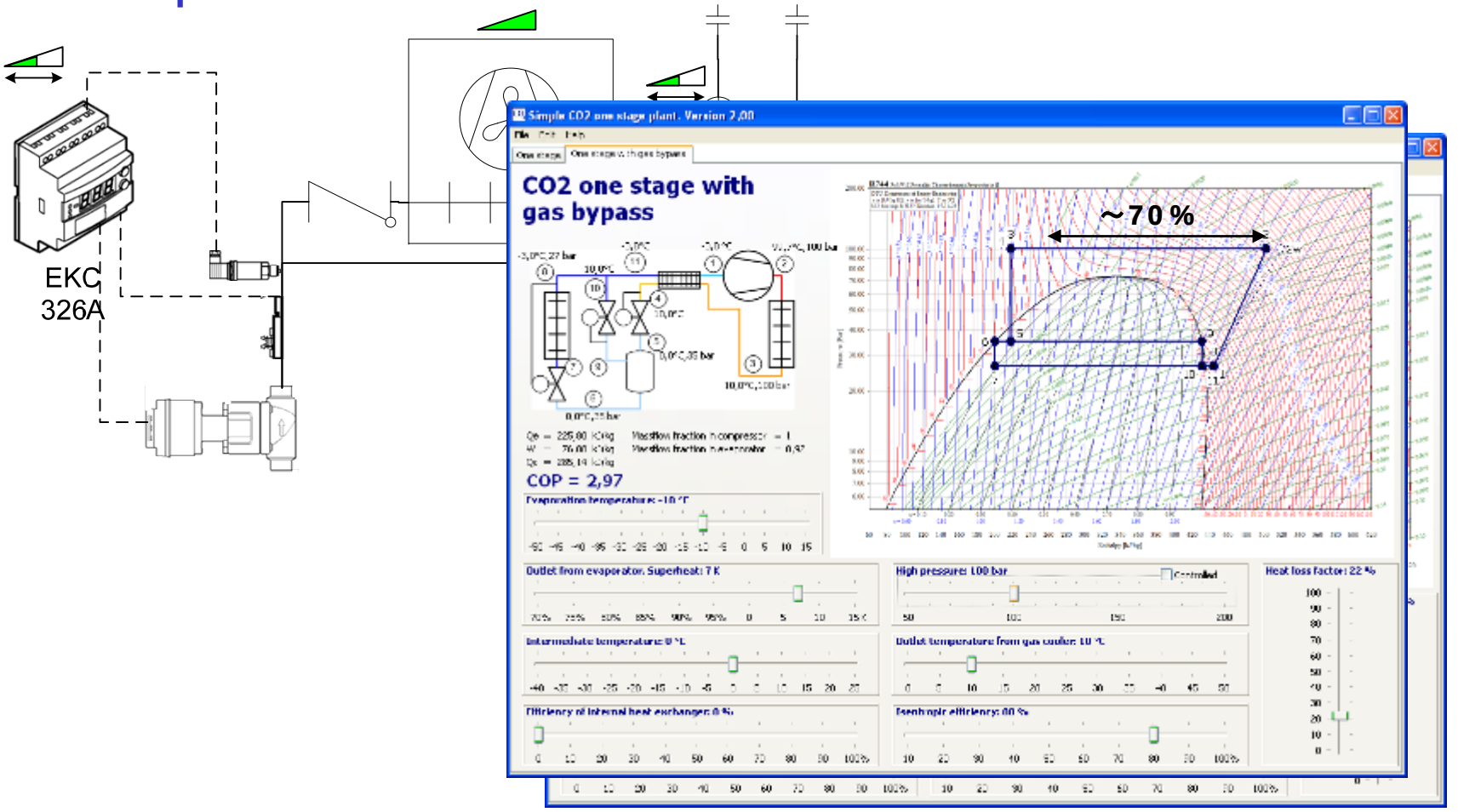
PI diagram



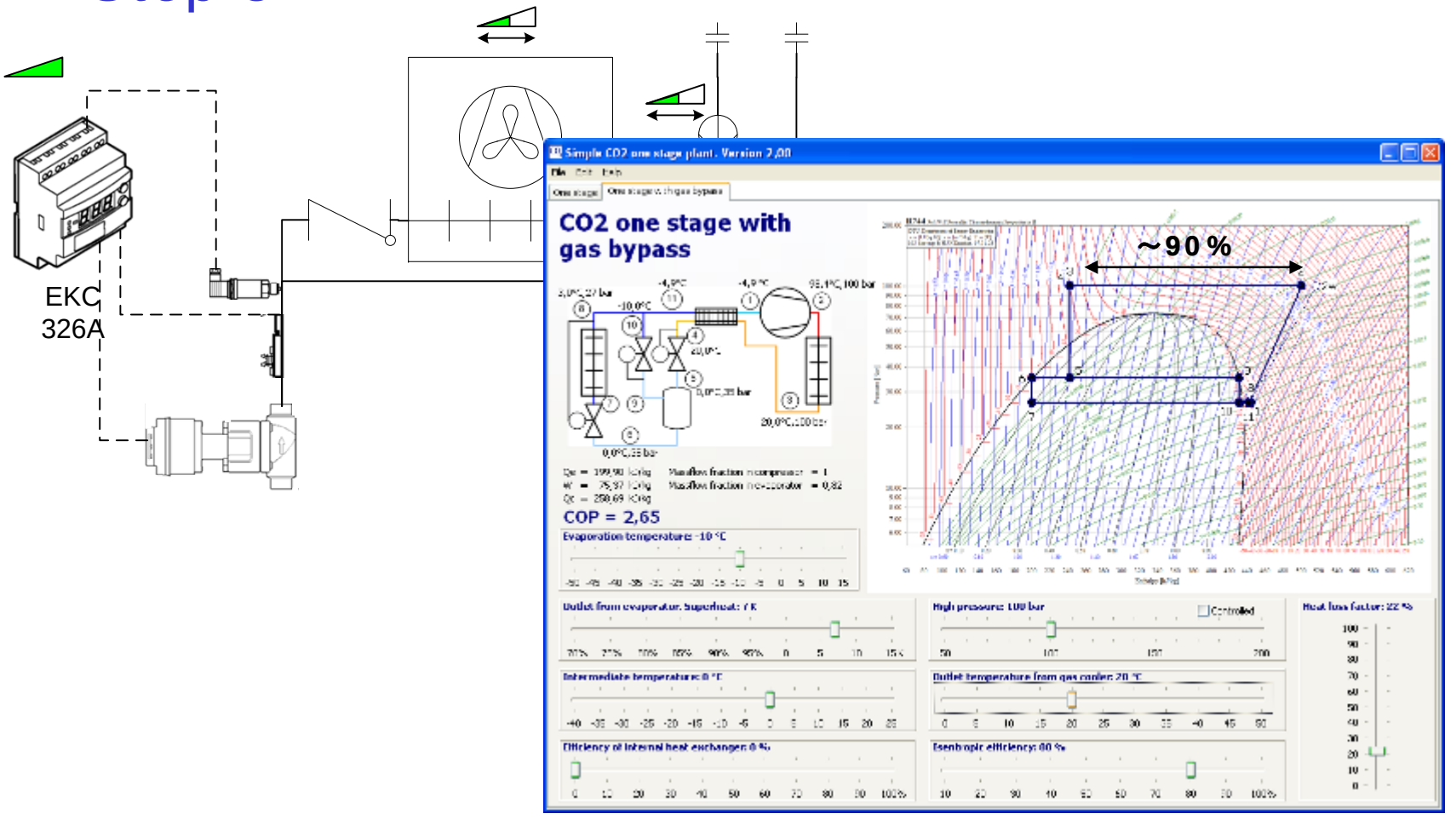
Step 1


EKC
326A
Simple CO2 one stage plant. Version 2.00
CO2 one stage with
gas bypass
COP = 7,36
Evaporation temperature: -10 °C
Outlet from evaporator : Super heat: 7 K
High pressure: 47 bar
Intermediate temperature: 0 °C
Outlet temperature from gas cooler: 10 °C
Efficiency of internal heat exchanger: 0 %
Isentropic efficiency: 80 %

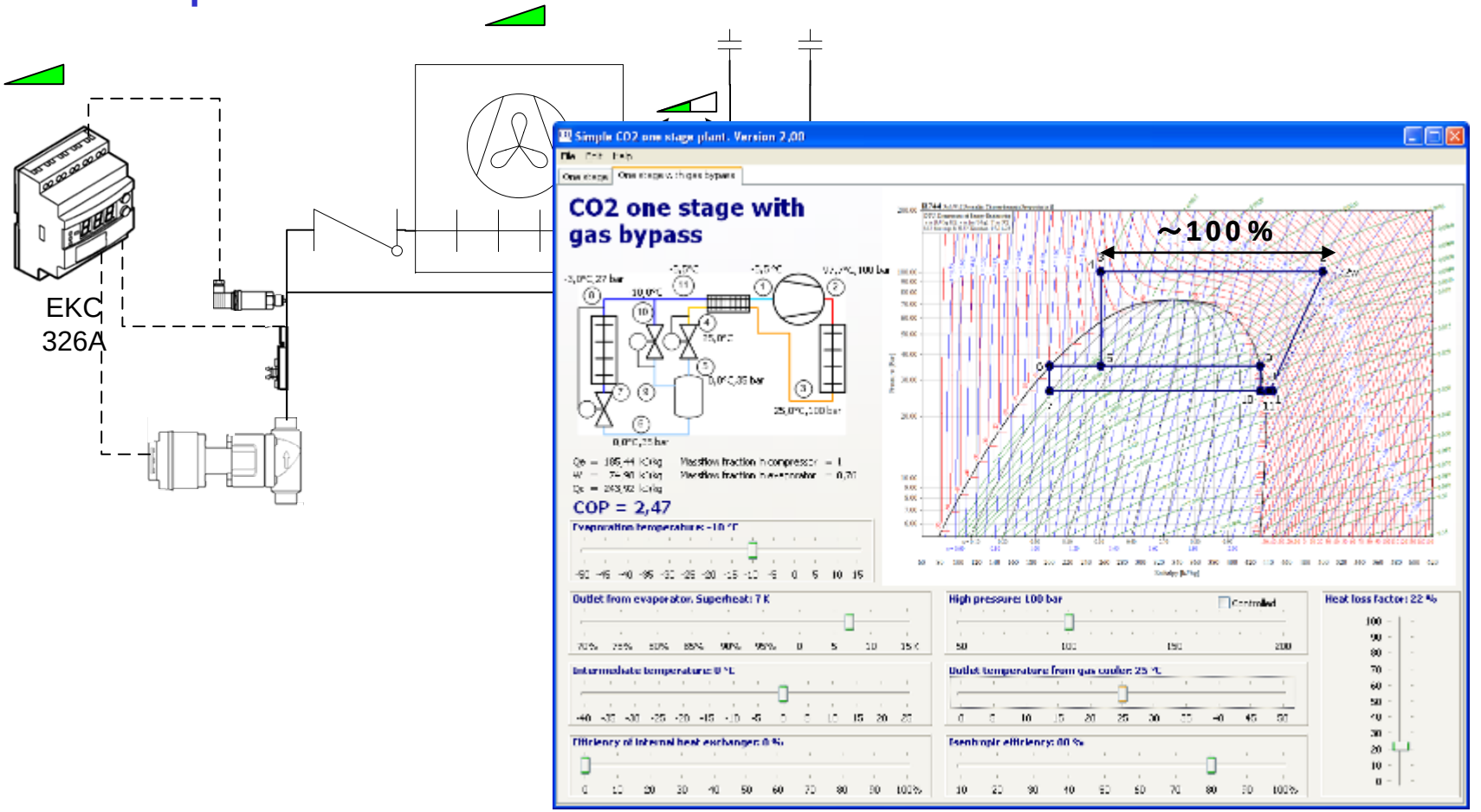
Step 2


EKC
326A
Simple CO2 one stage plant. Version 2.00
CO2 one stage with
gas bypass
COP = 2,97
~70 %

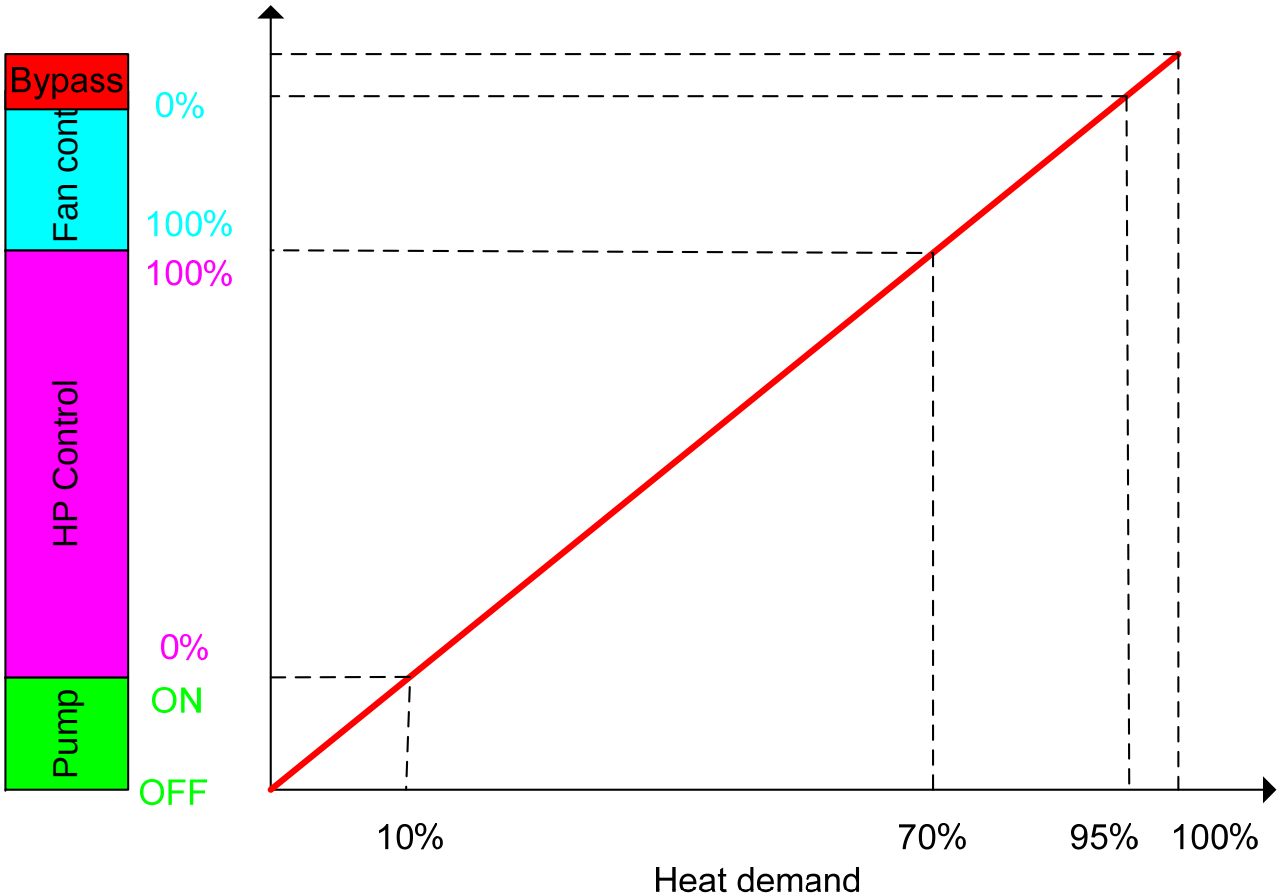
Step 3


EKC
326A
Simple CO2 one stage plant. Version 2,00
CO2 one stage with
gas bypass
~90 %
COP = 2,65
Evaporation temperature: -10 °C

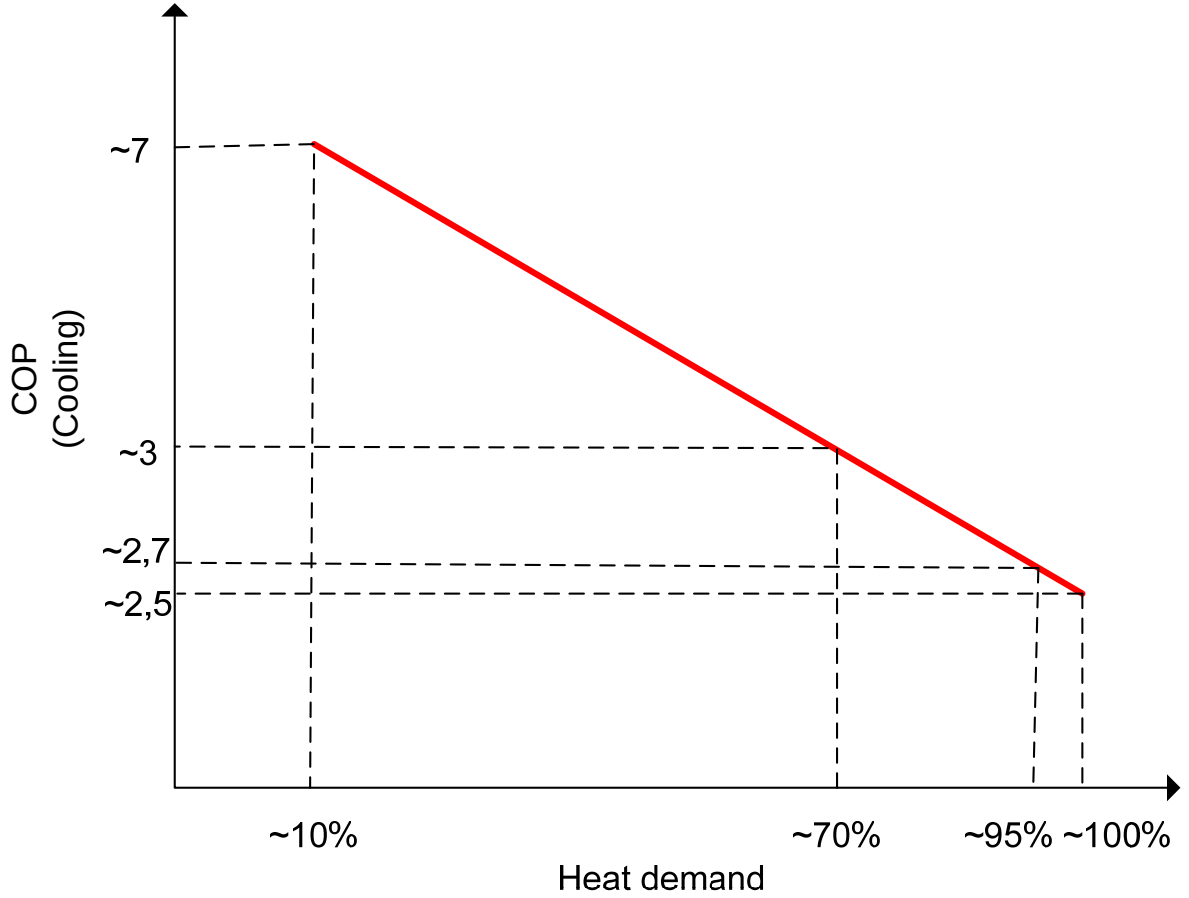
Step 4


EKC
326A
Simple CO2 one stage plant. Version 2,00
CO2 one stage with gas bypass
COP = 2,47
~100 %

Control principal



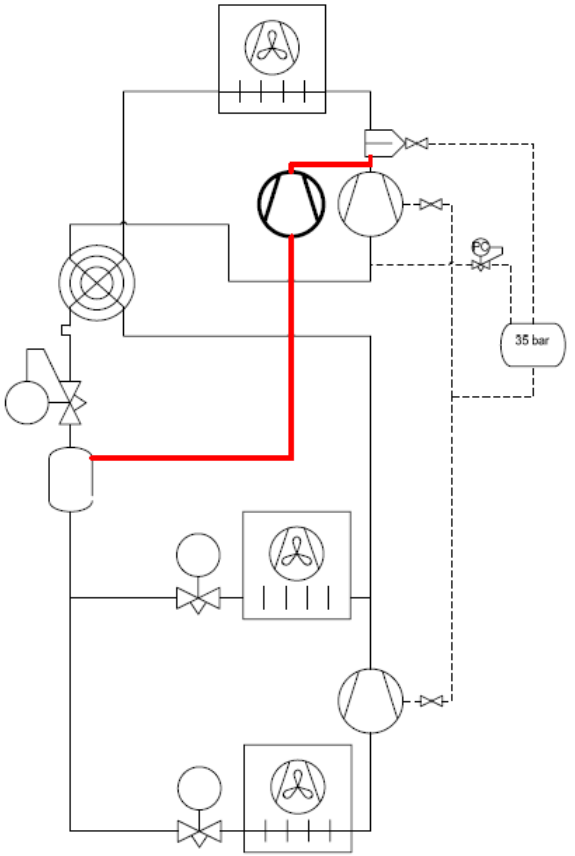
Efficiency



Parallel compression

Parallel compression

- Loss of capacity at high ambient temperature is one drawback of transcritical CO_2. This is in the nature of the cycle but can be handled in different ways.
  - Expansion machines (improves COP and capacity at high temperatures)
  - Ejector creating a higher suction pressure for the compressors (improves COP and capacity at high temperatures)
  - Parallel compression (improves COP and capacity at high temperatures)



Bitzer

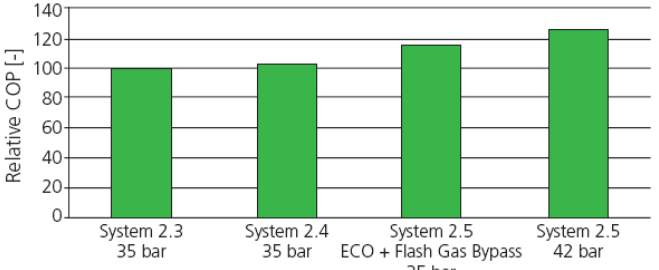
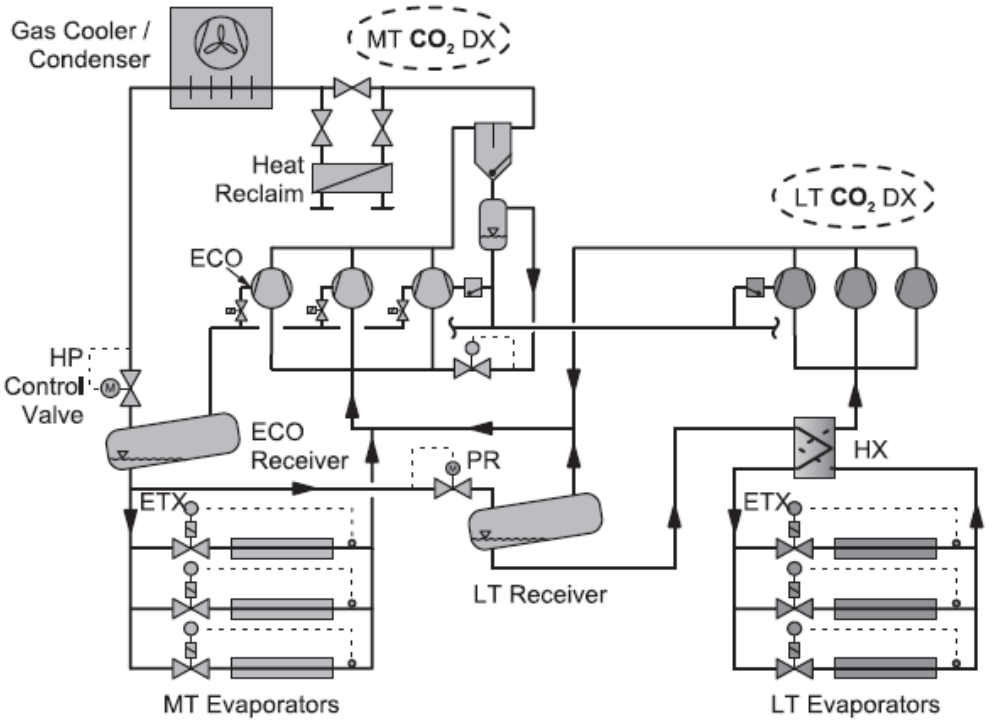


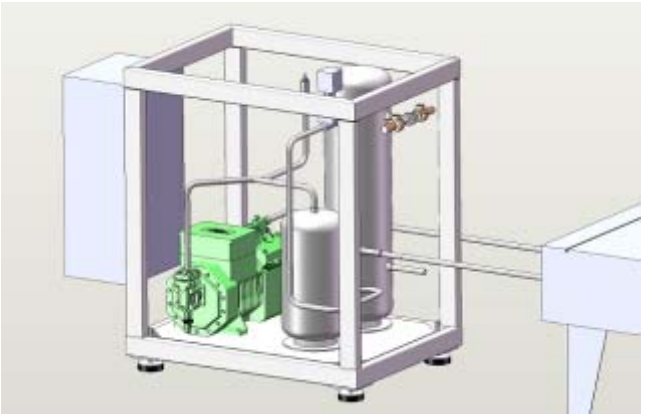
Figure 3. Comparison of system COPs.



Application examples

Small systems

- Today this segment is covered by condensing units with charges smaller than 10 kg



Small systems

- System for a REMA 1000 (24kW MT / 10kW LT) in Sabro near Århus Denmark
- Transcritical booster system with gas bypass
- 1 compressor for LT with AKD (30-70 Hz)
- 2 compressors for MT, 1 with AKD (30-70Hz)
- Uses Service tool as front end

Medium size systems

- Standard system from a medium size COOP supermarket.
- Approx 60kW MT and 20 kW LT

Large systems

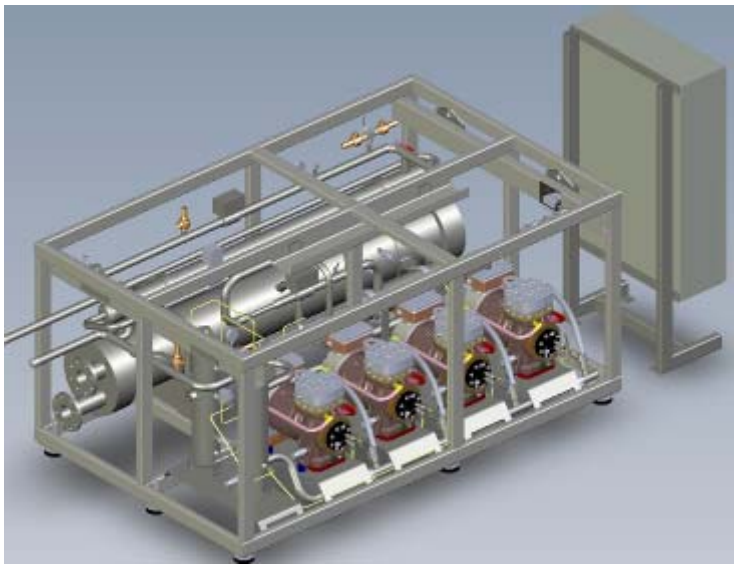
- Netto Central storage facility vest of Århus (Denmark)
- Total installed capacity approx 1,5 MW (4 MT systems and 2 LT systems)
- Transcritical gas by pass system (Cascade)
- Start up November 2009
- 20% lower installation costs
- 1,2 MW heat reclaim (40-70 ºC water)

Large systems

- Storage of fruit and vegetables Måkested Norway:
- Booster with gas-by-pass, DX
- Capacity: 2 x 400 kW
- Evaporation temperature: -10ºC/ -35ºC
- Economy: 20 % saving on installation and approx 20 % saving on energy.
  Compared to cascade systems

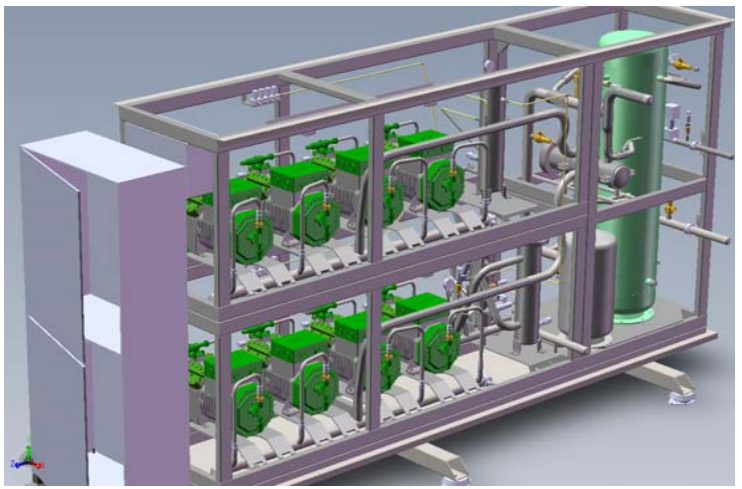
Heat pumps

- From a technical point of view CO_2 is unique in heat pump applications.
- With CO_2 it is possible to make high temperature lifts and achieve high media temperatures.
- Thin makes CO_2 unique in some applications, but not necessarily the best solution in all cases.



Parken in Copenhagen – AC with DX CO2

- Gas by-pass system with DX CO_2
- 3 x 400 kW installed capacity
- Evaporation temperature 7-8 ºC
- Air temperature
- Economy: 20% saving on installation and 15% saving on energy compared with high-end HFC chillers



Experience

- Approx 1200 transcritical systems are installed in the Nordic countries (2010). This is every day business!!!
- All supermarket groups in Denmark except Netto has transcritical CO_2 as the only option in there specification
- Gas by-pass systems seems to have taken a very large market share because of technical superiority and low complexity.
- Energy consumption seems to be at the same level as HFC systems
- Heat reclaim looks very promising.

Pack manufactures

- Advansor, Denmark
- Fischer Gmbh, Germany
- Green & Cool, Sweden
- Knudsen Køling, Denmark
- Midtjysk køleservice, Denmark
- PVN køleservice, Denmark
- SCM frigo, Italy