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Performance analysis of a heat pump system providing district heating and cooling through gradual heating and cooling

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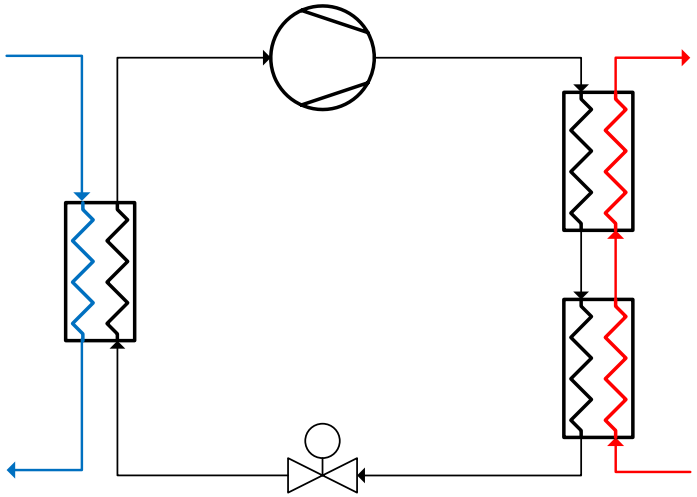
Introduction

Power2

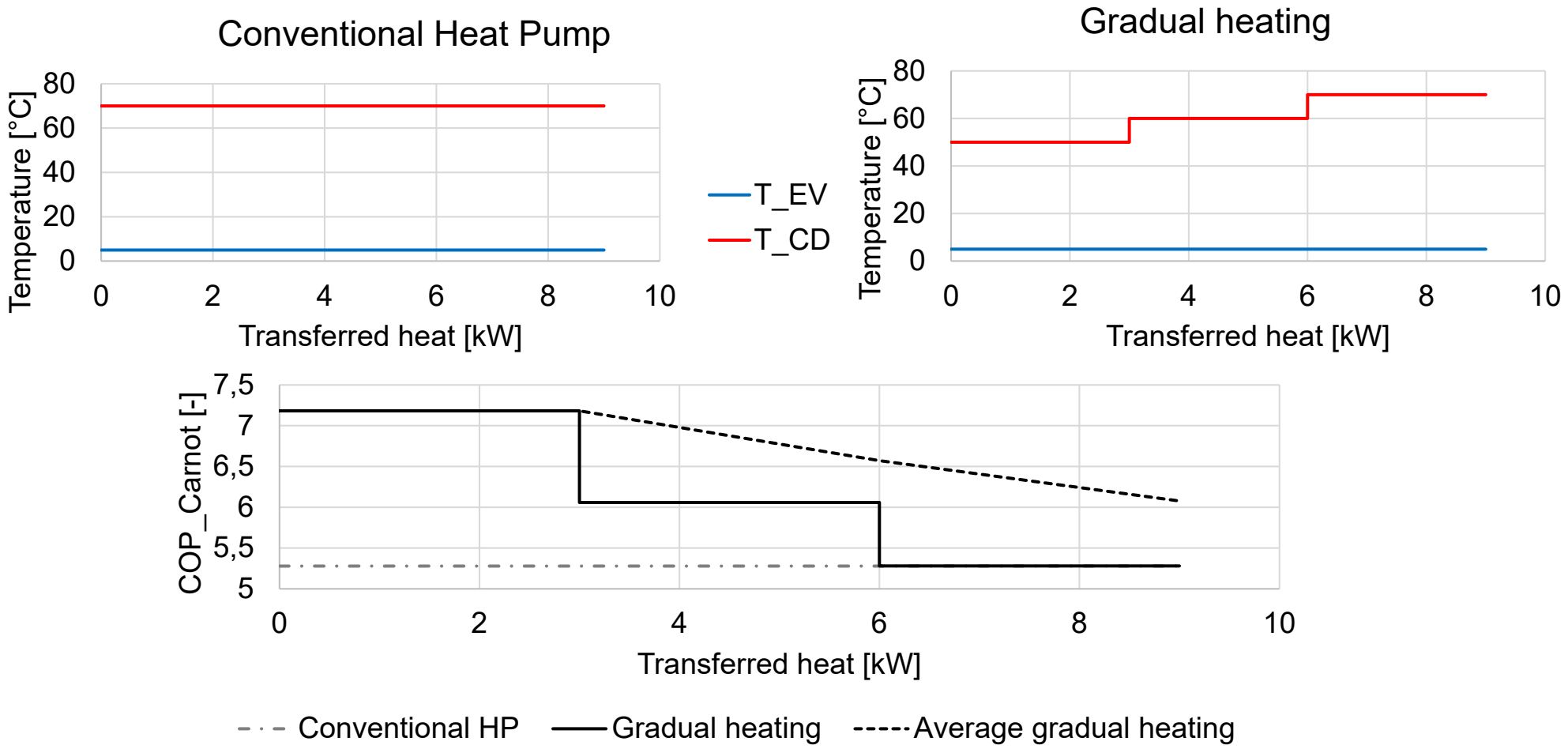
Heat/Cold



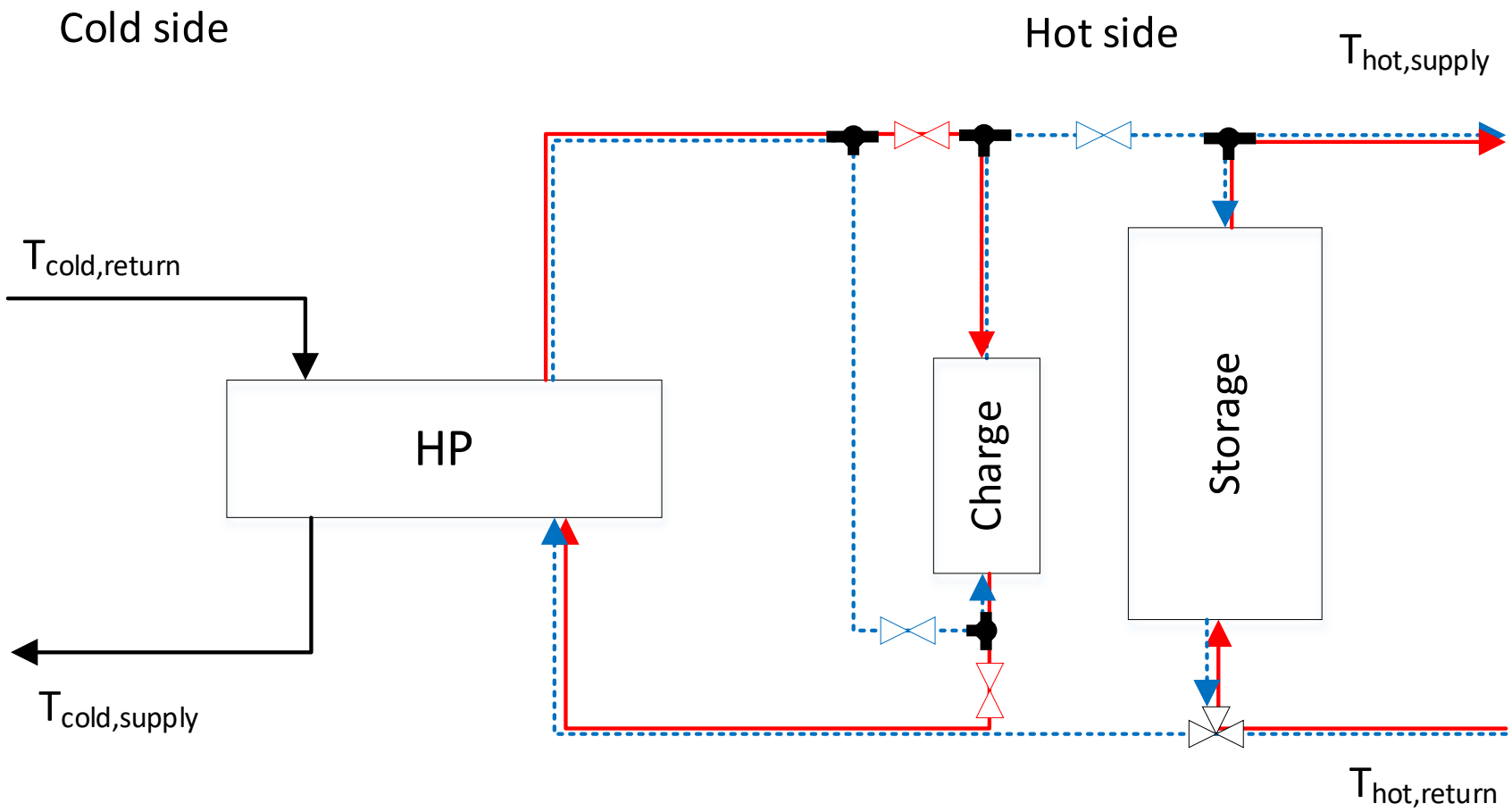
COP ↑↑↑

$$$ ↓↓↓

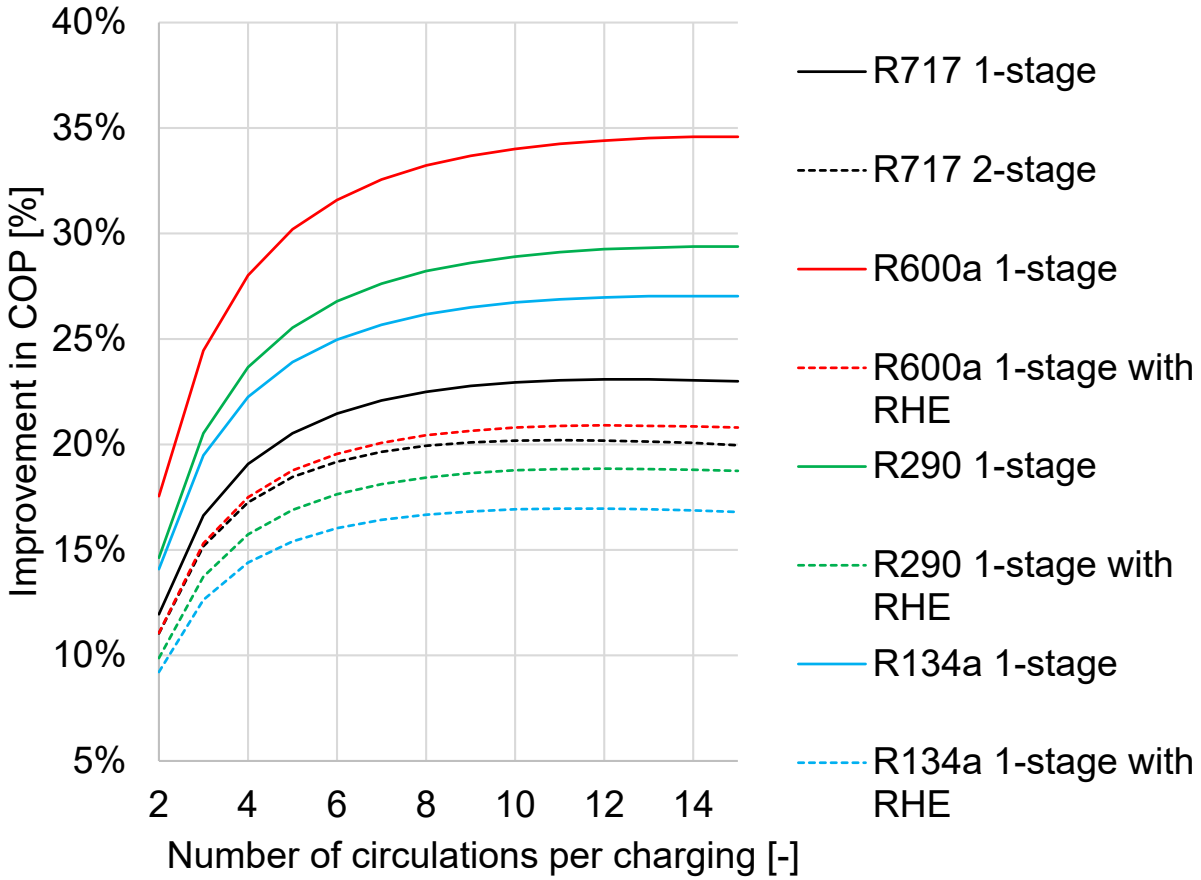
Motivation gradual heating

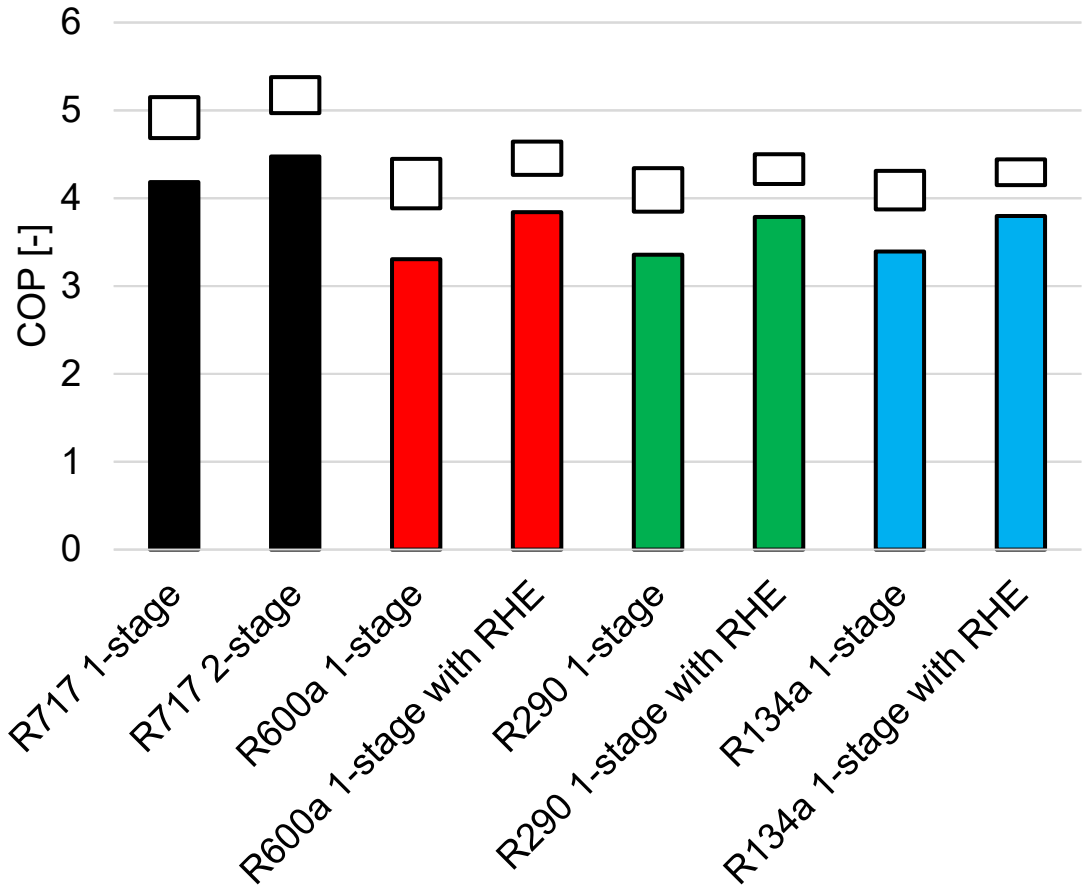


Gradual heating with ISECOP system



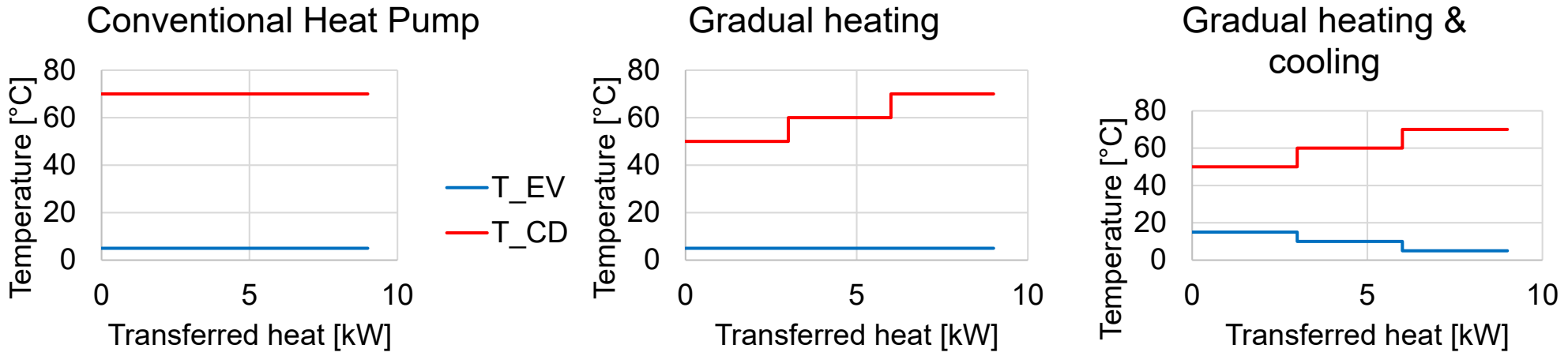
Results gradual heating

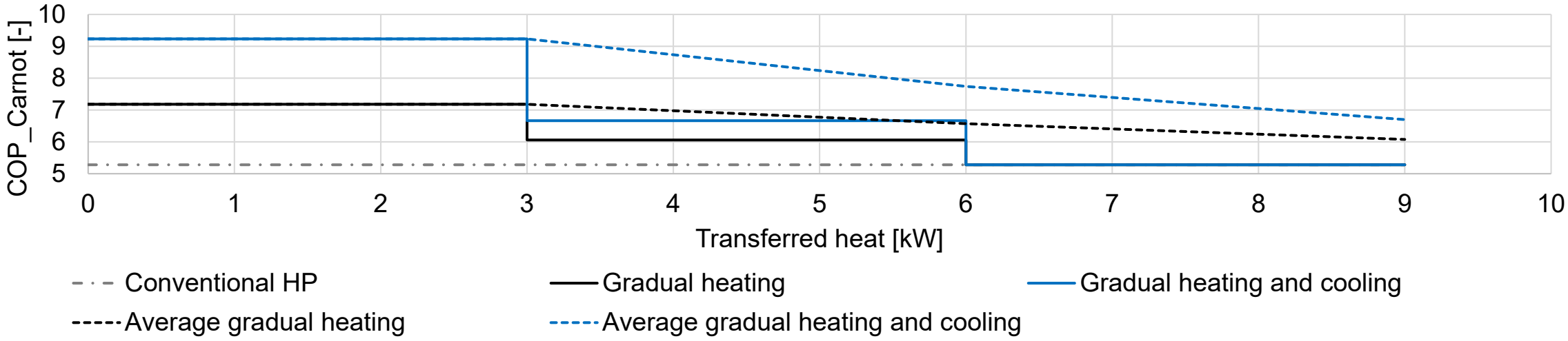




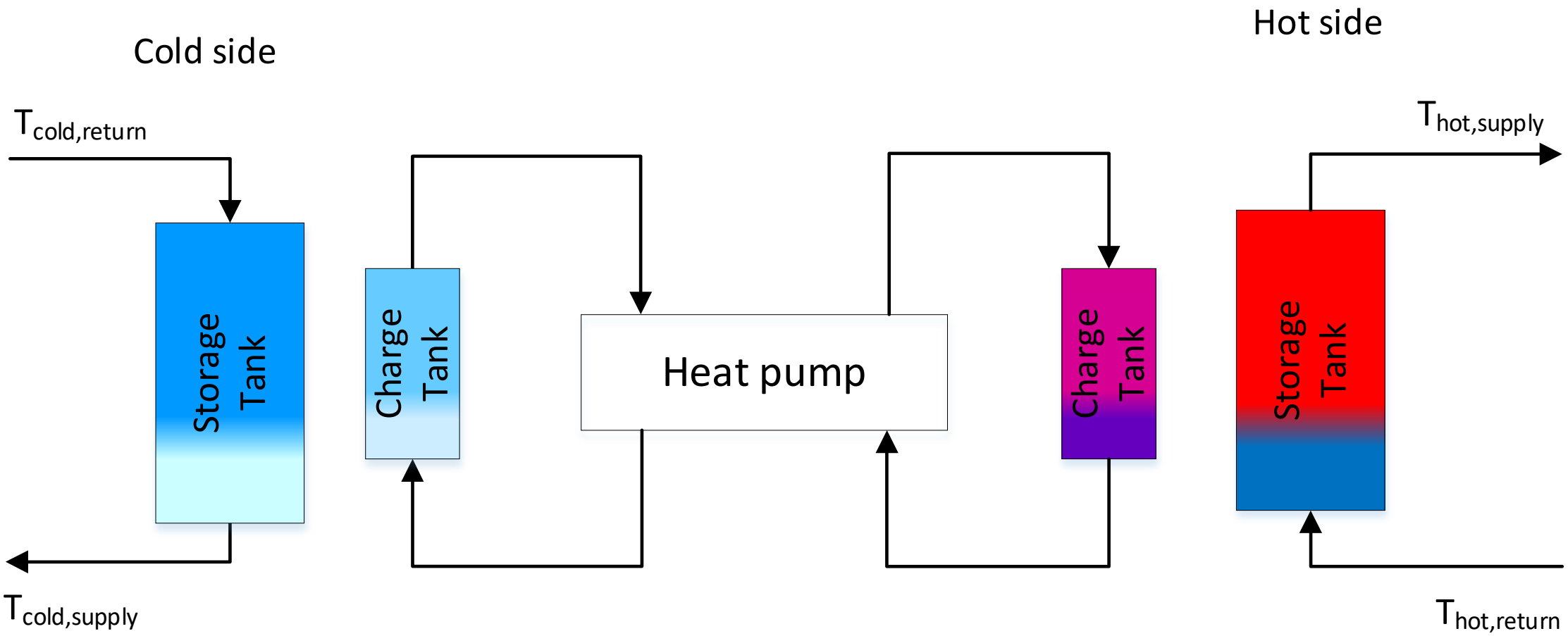
Kofler et al., 2019. Screening of heat pump performance improvements obtained through gradual heating using a tank system. Proceedings of the 25th International Congress of Refrigeration, International Institute of Refrigeration.

Motivation gradual heating & cooling



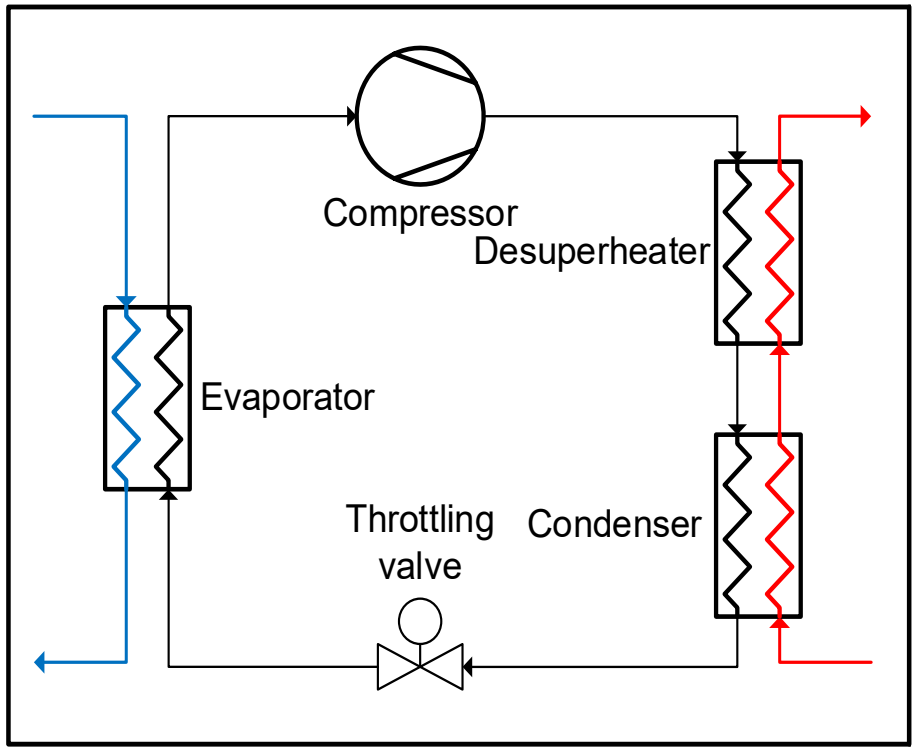


Gradual heating & cooling with ISECOP system



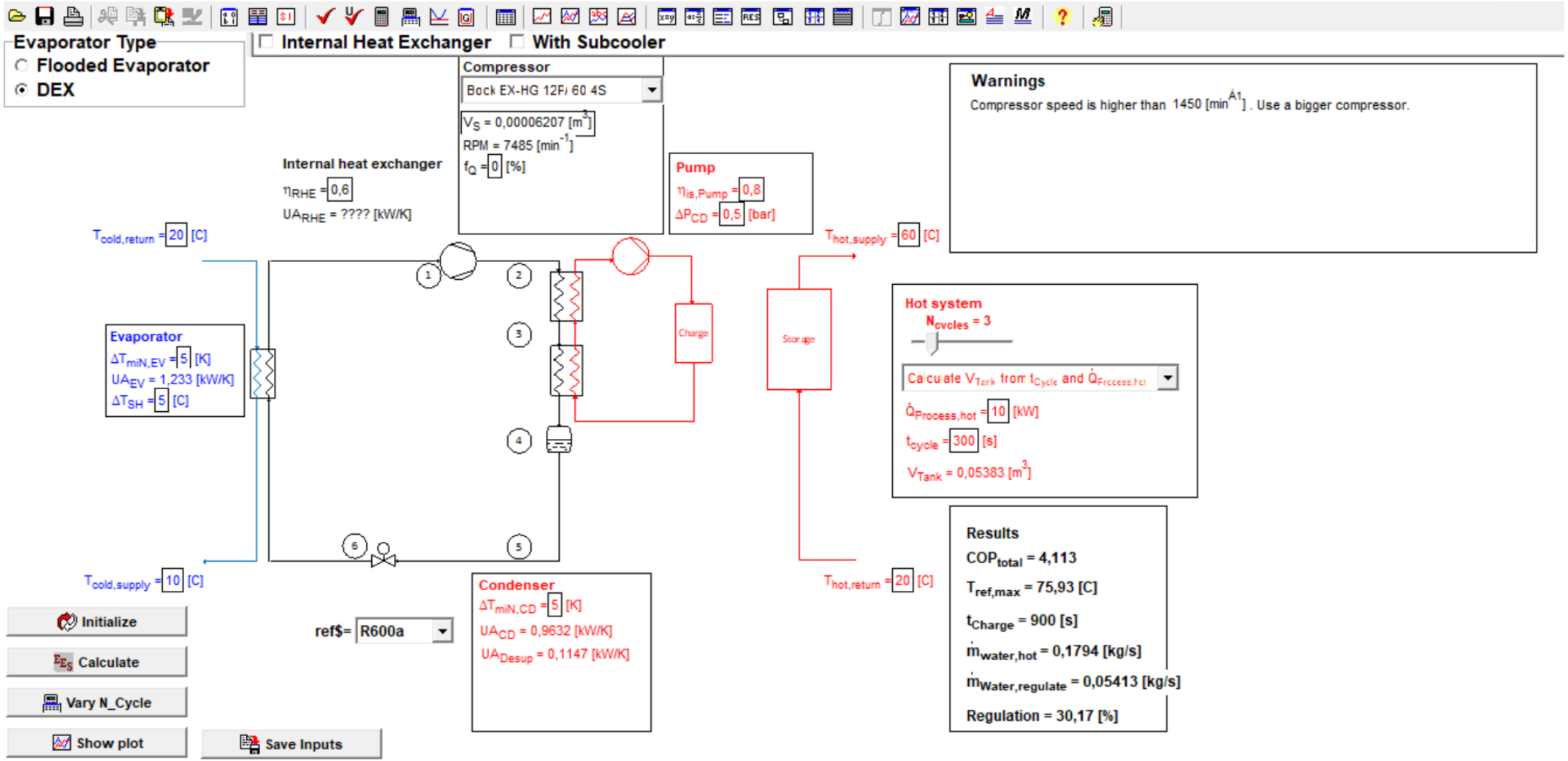
Case study

One-stage cycle



- Refrigerants:
  - Ammonia (300 kW)
  - R600a (10 kW)
- District heating
  - Return temperature 40 °C
  - Supply temperature 70 °C
- District cooling
  - Return temperature 15 °C
  - Supply temperature 8 °C

Simulation tool in EES

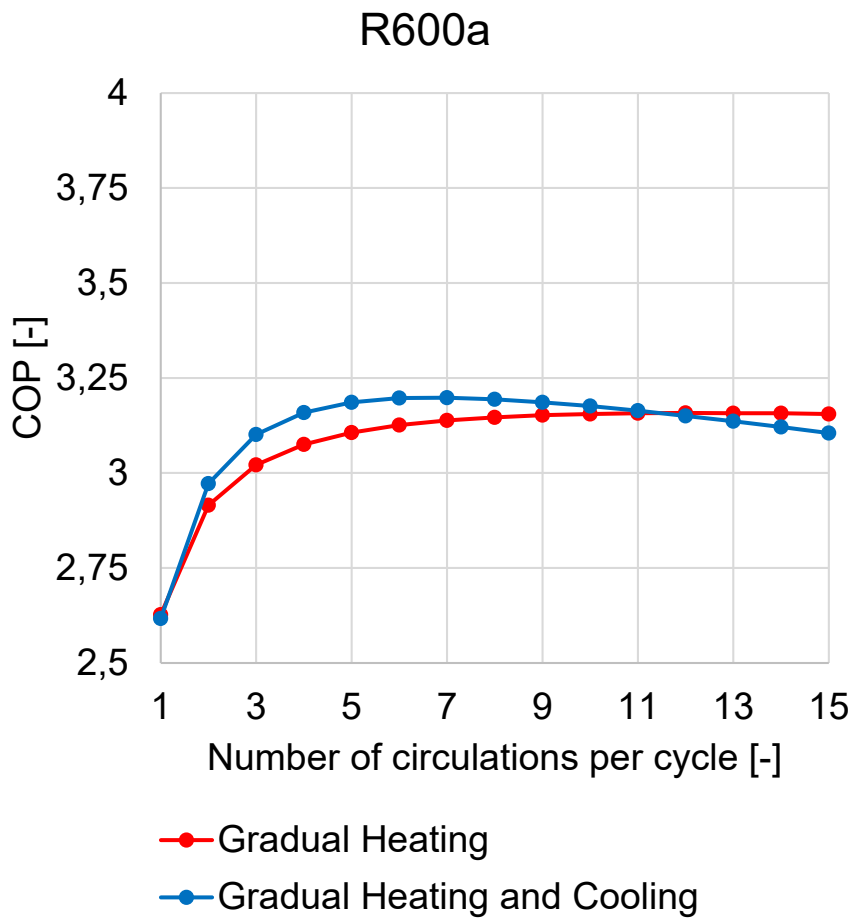


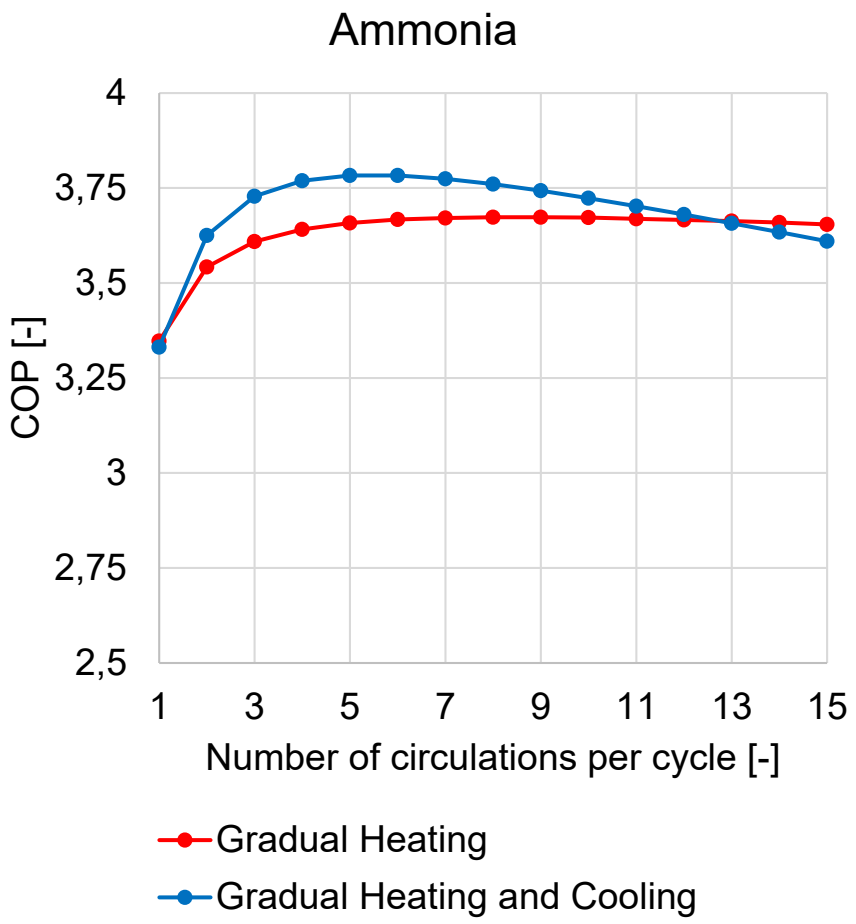
Assumptions

- Quasi-steady-state model
- Ideally stratified tanks without heat losses
- Same number of circulations through condenser and evaporator
- Constant water mass flow throughout the charging
- Constant compressor speed
- Constant UA-value for all HEX

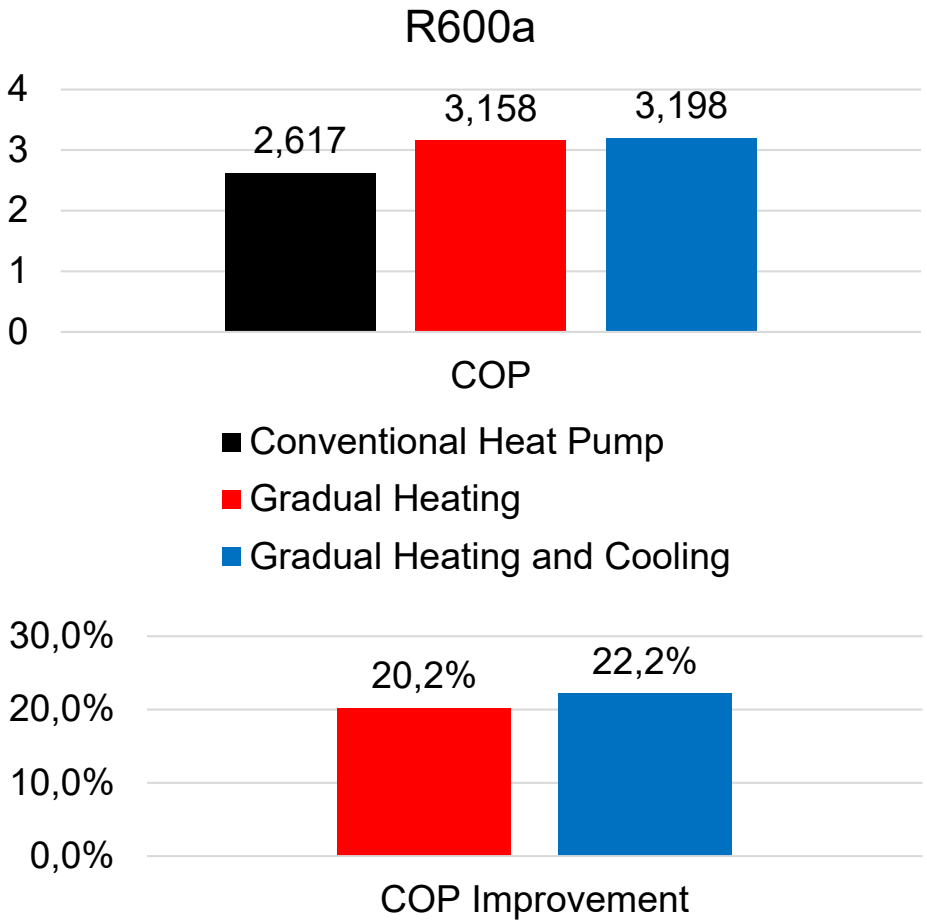
Working fluid	R717	R600a
Compressor suction superheat [K]	0	5
Max. discharge temperature [°C]	180	180
Pinch point temperature difference [K]	5	5
Pressure drop in condenser and evaporator [bar]	0.5	0.5
Pump isentropic efficiency [-]	0.8	0.8
Compressor model	Sabroe HPX-708	Bock EX-HG 12P/60 4S

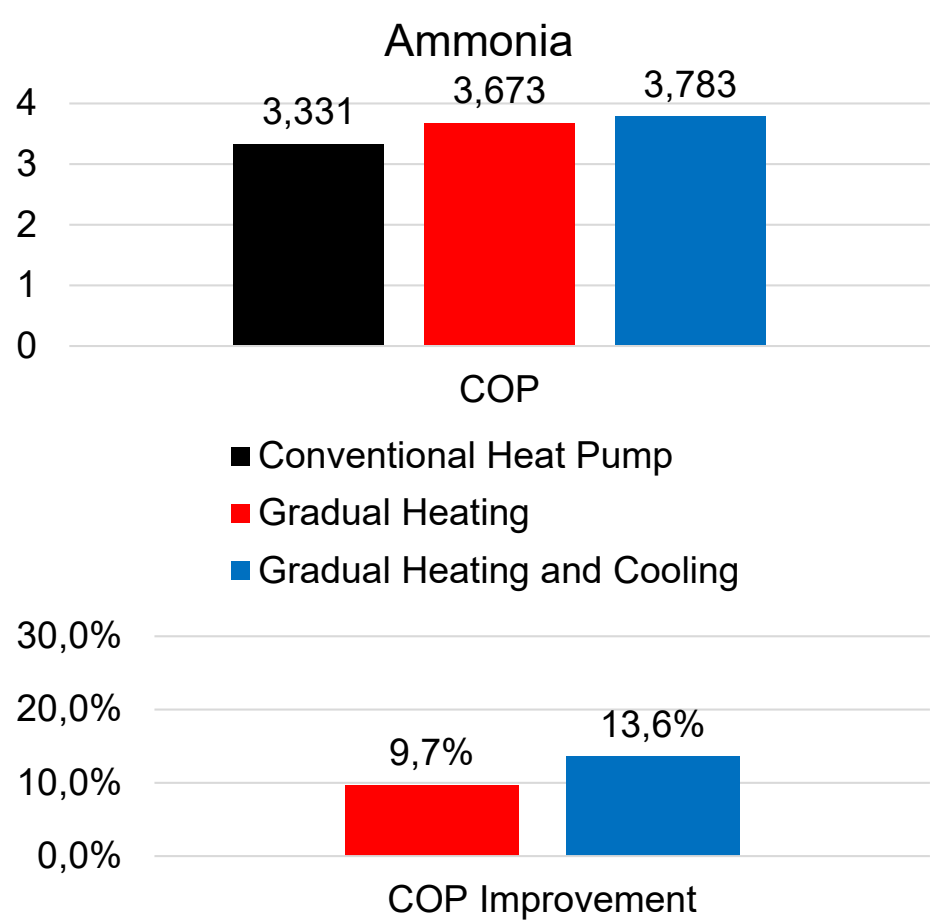
COP over N


R600a
4
3,75
3,5
3,25
3
2,75
2,5
COP [-]
1
3
5
7
9
11
13
15
Number of circulations per cycle [-]
Gradual Heating
Gradual Heating and Cooling

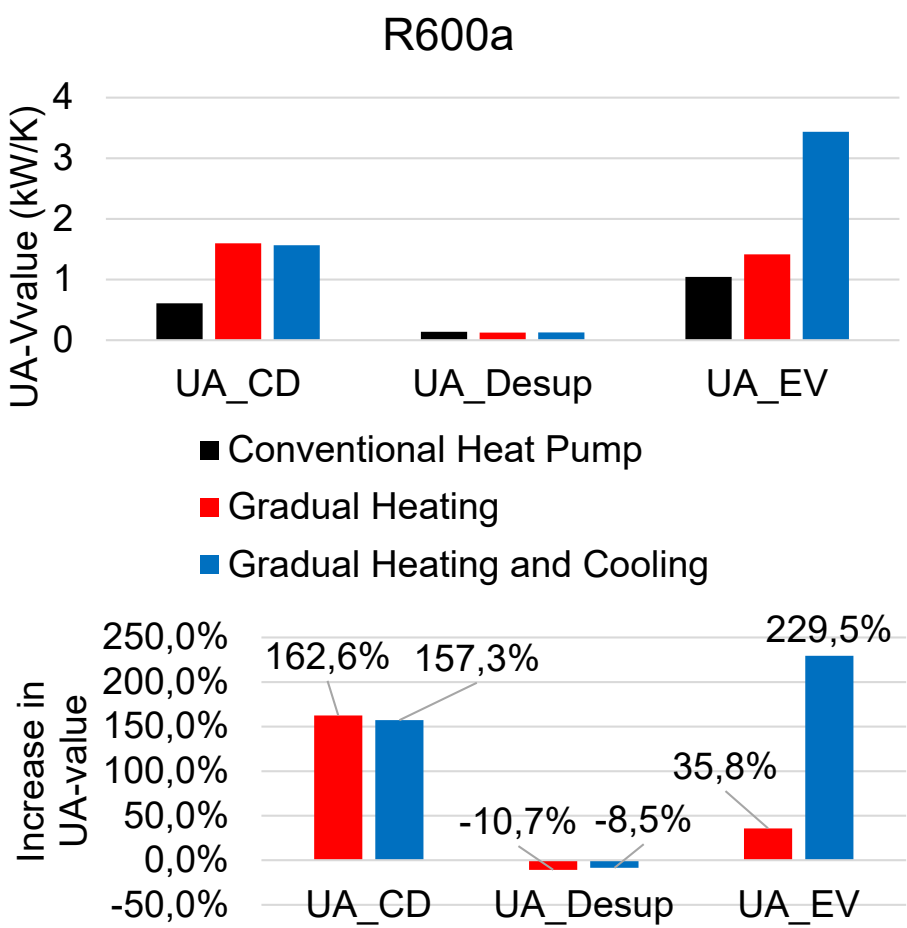

Ammonia
4
3,75
3,5
3,25
3
2,75
2,5
COP [-]
1
3
5
7
9
11
13
15
Number of circulations per cycle [-]
Gradual Heating
Gradual Heating and Cooling

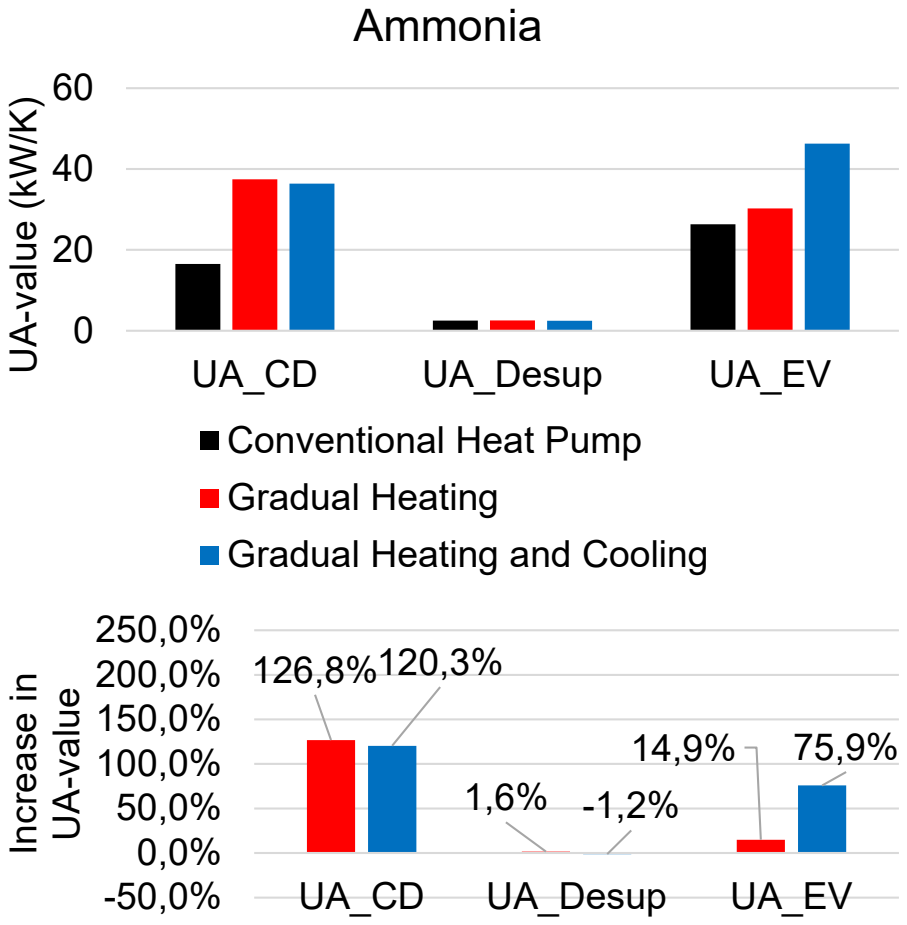
Maximum COP improvement





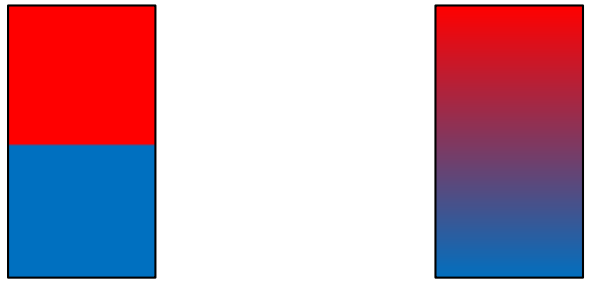
Influence on heat exchanger size



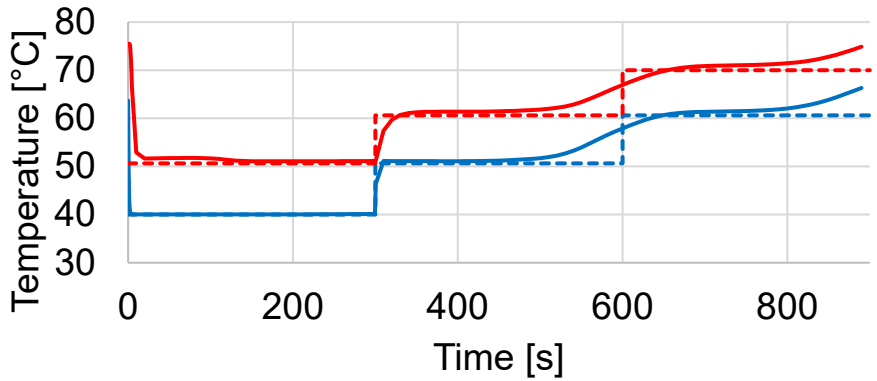


Discussion

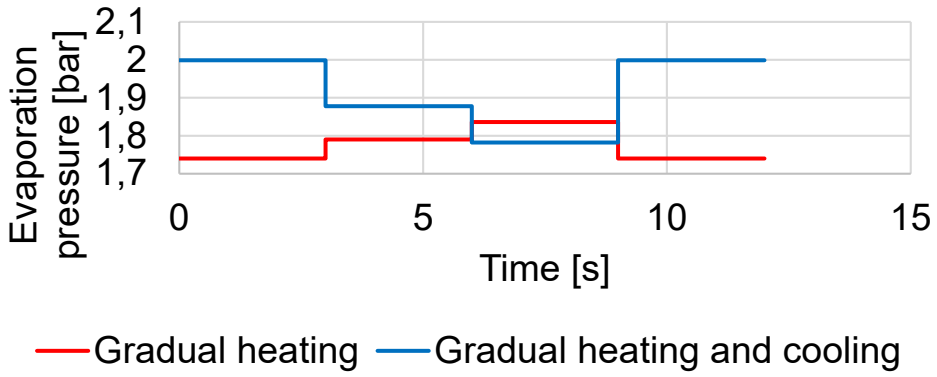
- Neglected heat transfer, mixing and heat loss in tanks



- Dynamic behaviour of heat pump
  - Thermal inertia
  - Control strategy



- Sudden increase in evaporation pressure
  - Potential problem with condensation in suction line



Conclusion

- Using the ISECOP system can improve the performance of a heat pump providing district heating and cooling
  - Gradual heating: 20.2 % (R600a) & 9.7 % (R717)
  - Gradual heating and cooling: 22.2 % (R600a) & 13.6 % (R717)

- Gradual heating and cooling leads to increase in evaporator size
  - Investment costs will be significantly higher than for conventional heat pump and gradual heating

Thank you for your attention!

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