Closed loop heat pumps

Initial situation, expectations and results

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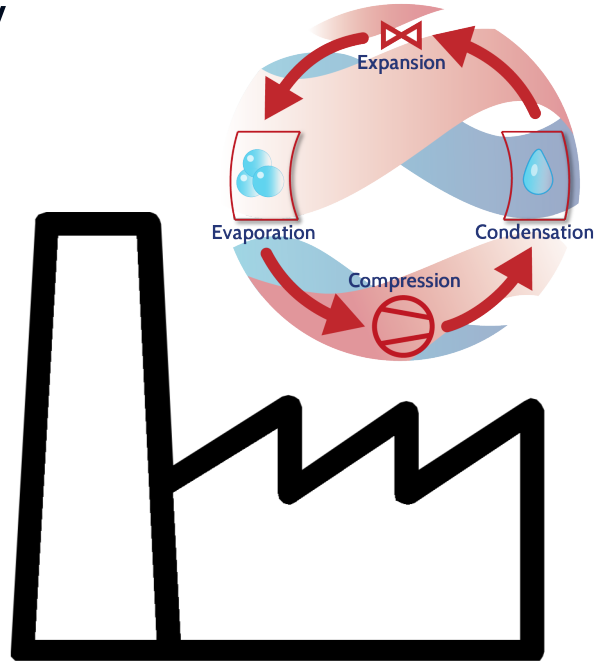
How it all started…

- 12 kW heat pump with R1336mzz(Z)
- Experimental investigation in AIT‘s lab
- Condensation temperatures up to 160ºC

- Drying chamber with heat pump at WBG
- Process analysis for HP integration at AGA

Expectations

- develop a viable solution for industrial waste heat recovery
- increase heat supply temperatures up to 160ºC
- solve the challenges for components
  - compressor
  - lubricant
  - refrigerant
- demonstration in industry



Videos

Grant Agreement No 723576 – Energy Efficiency

Technology development

Grant Agreement No 723576 – Energy Efficiency

Screw compressor development

CSH2T NEW COMPRESSOR GENERATION FOR HT APPLICATIONS

// **General features**

- SST max up to +75°C
- → max SGT up to +100°C (compressor inlet)
- → max DGT up to +140°C (compressor outlet)
- Operates with HFO HT Refrigerants

BITZER has started first field tests to gain more experience.

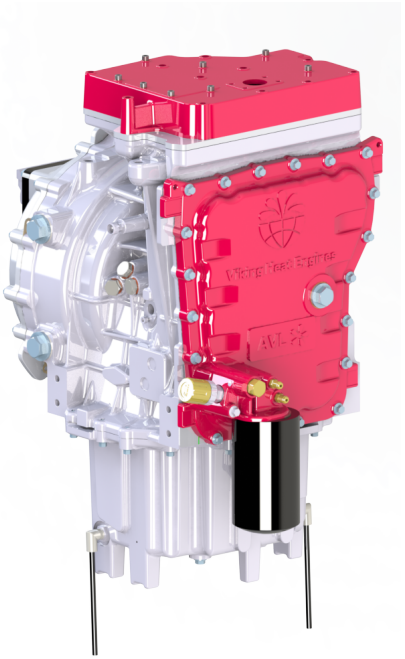
Piston compressor development

8 compressors at Wienerberger

- design based on an ORC expander
- operation as compressor due to change in the valve settings
- designed for R-1336mzz(Z)
- swept volume of 54 m³/h at 1800 rpm
- around 50 kWth output

Viking Heat Engines

HEATEN



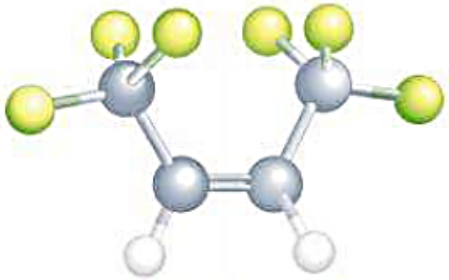
new product family with 1-8 MWth

- 1 MWth to be launched in 2022

Lubricant and refrigerant development

R-1336mzz(Z)

- A1 refrigerant (low toxicity, no flammability)
- GWP = 2, OPD = 0
- Critical temperature = 171ºC



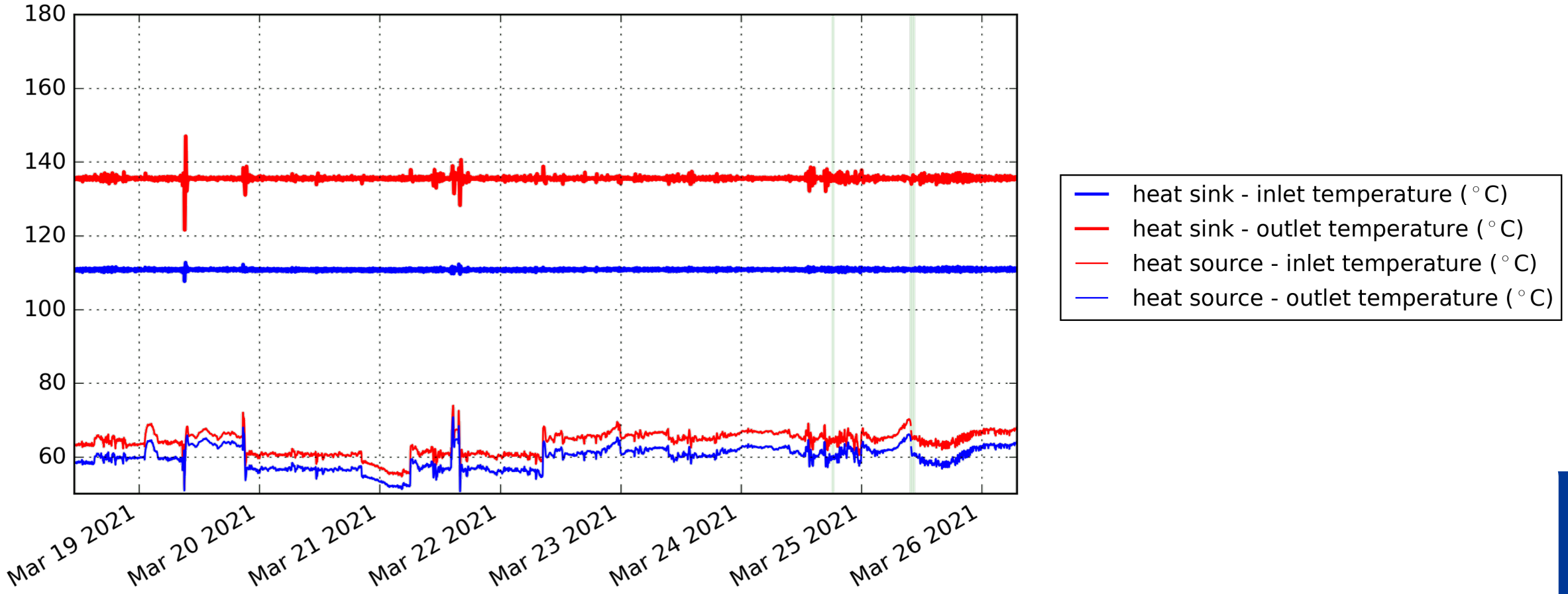
HFO-1336mzz-Z

PAG lubricant

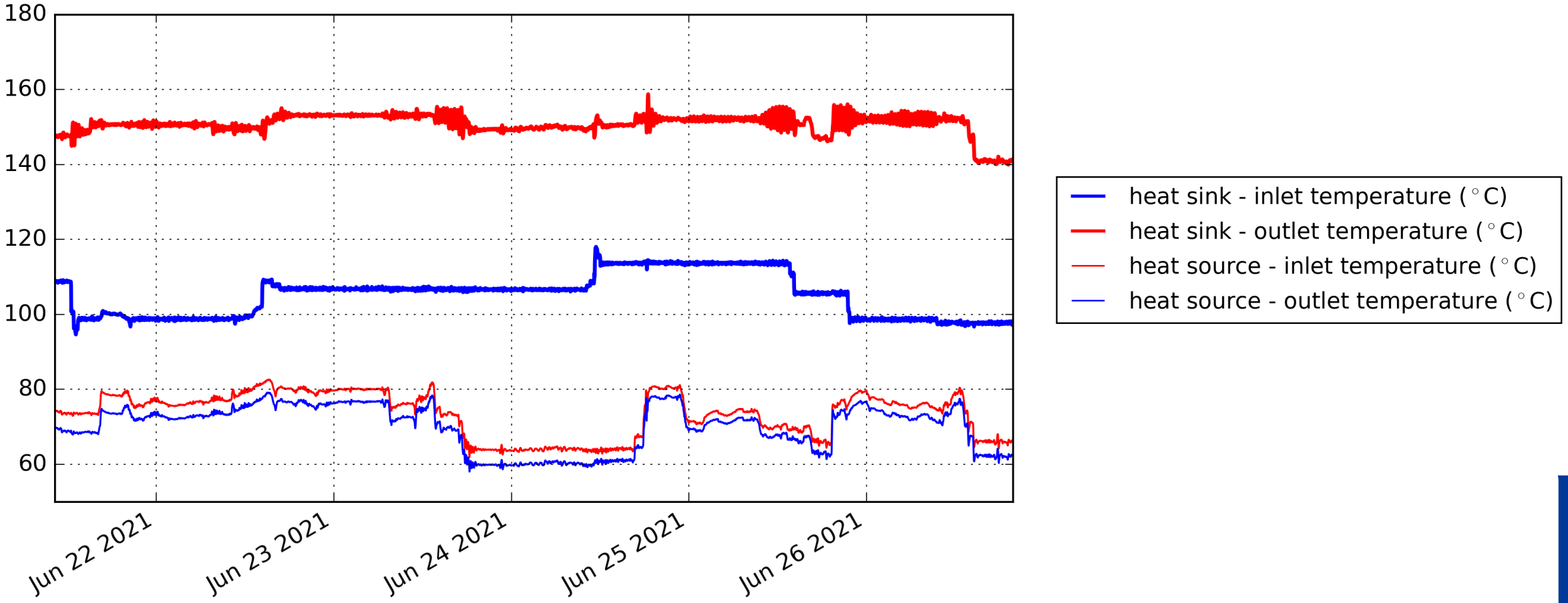
- Miscible with refrigerant
- Thermally and chemically stable with refrigerant
- High viscosity at high temperature and pressures

Operation of the demonstrators

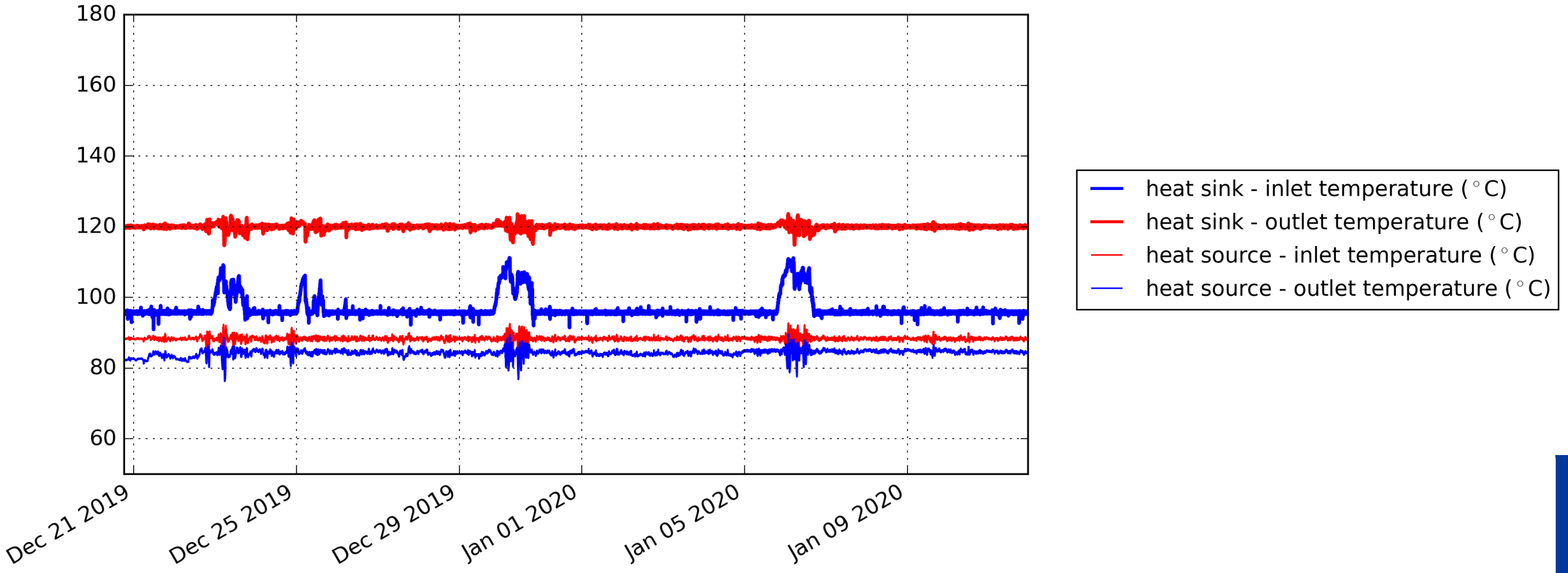
Performance: Agrana demonstrator



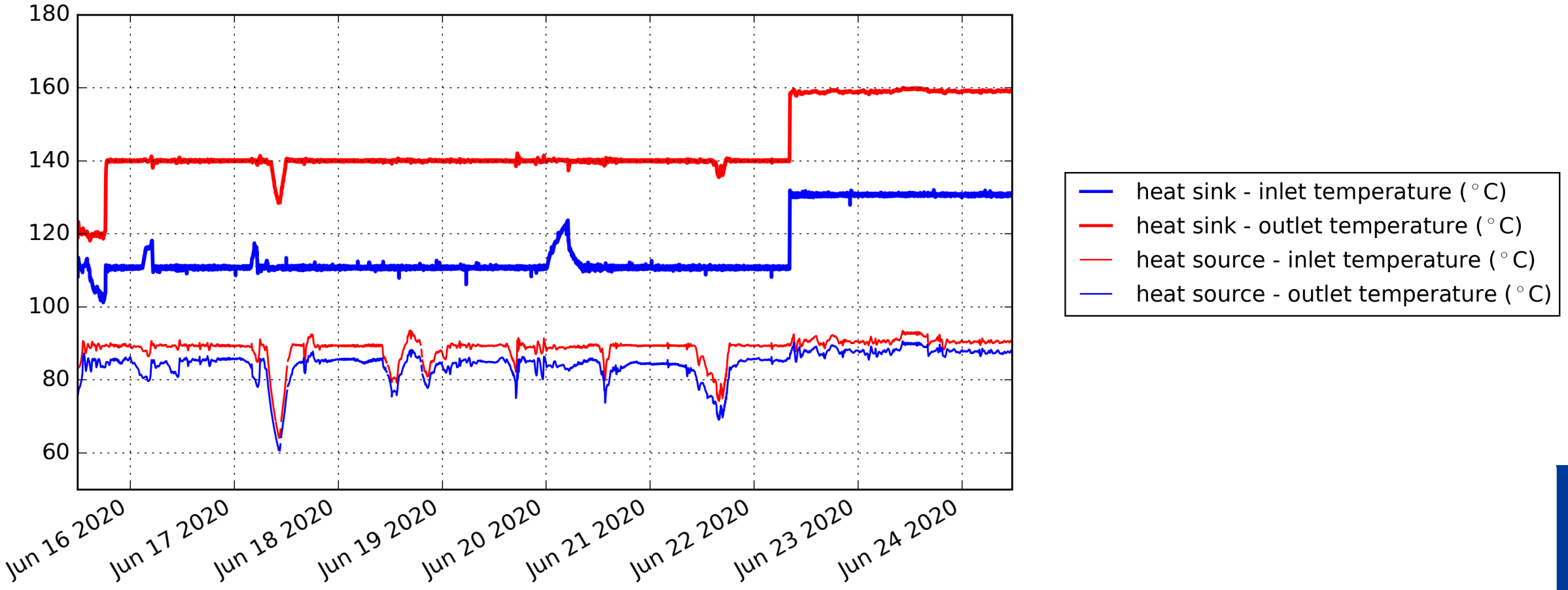
Performance: Agrana demonstrator



Performance: Wienerberger demonstrator

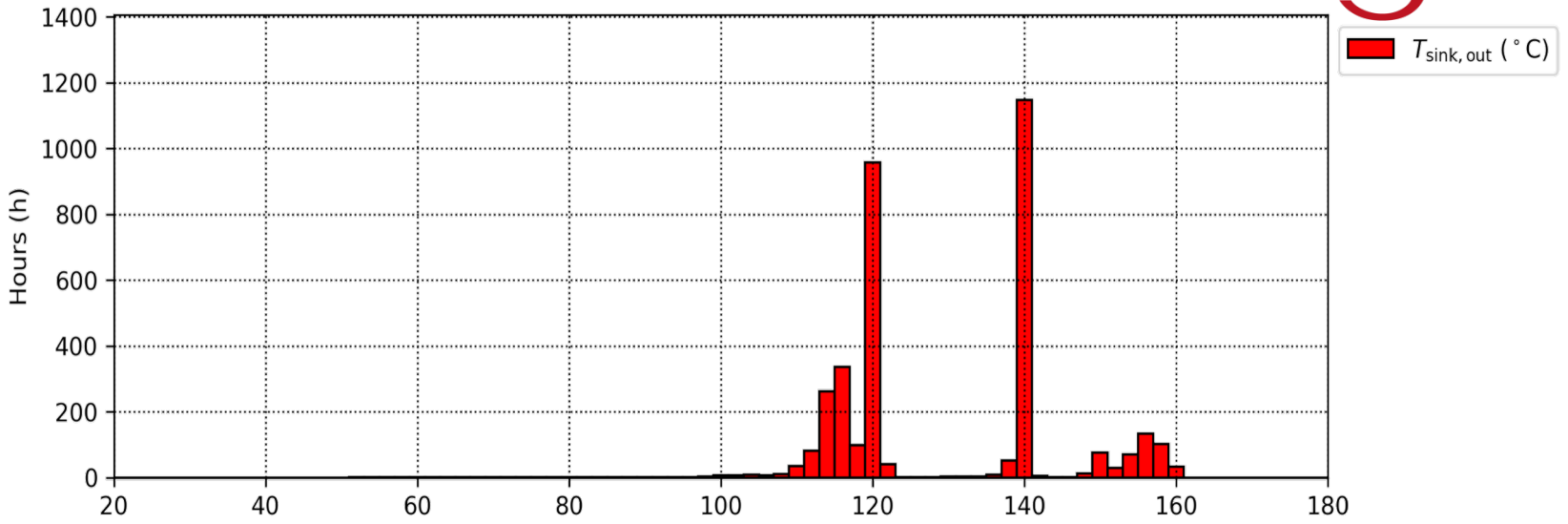


Performance: Wienerberger demonstrator

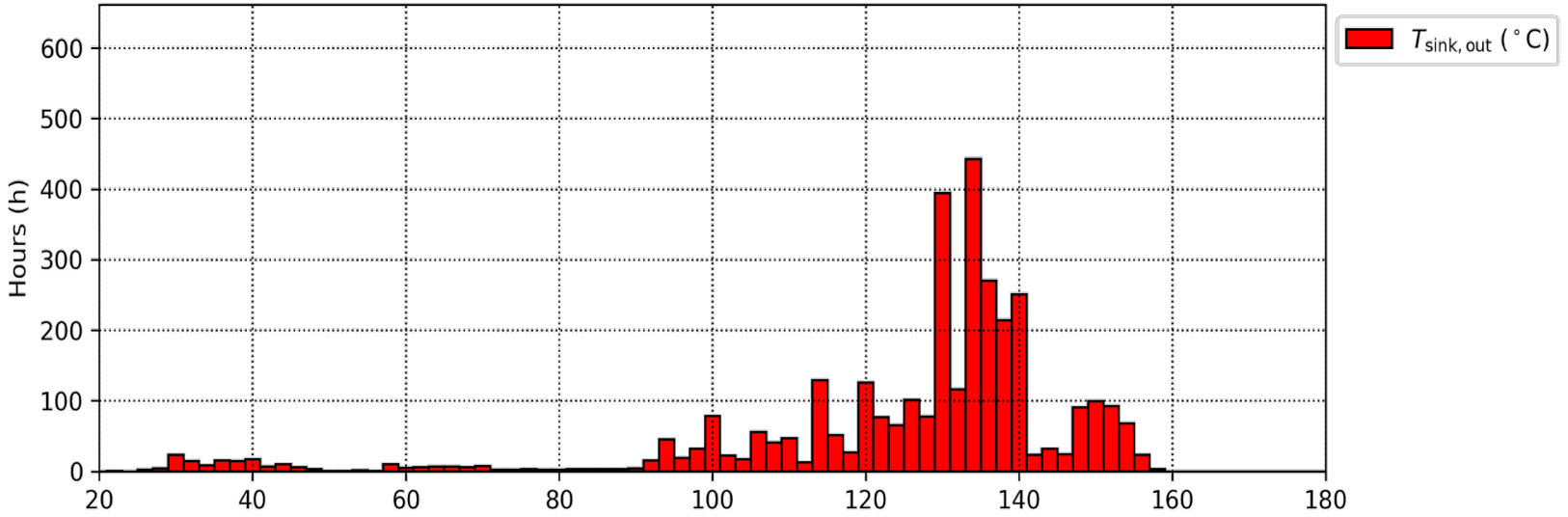


Performance: Operating hours

- WBG:
  3560 h until 30.6.2021



- AGA:
  3392 h until 30.6.2021



Challenges encountered during the development of DryFiciency

Global factors

- Corona pandemic
- lead times for materials

Material compatibility

- sealing materials for safety valves
- sealing materials in components

Mechanical design

- vibrations of piston compressors

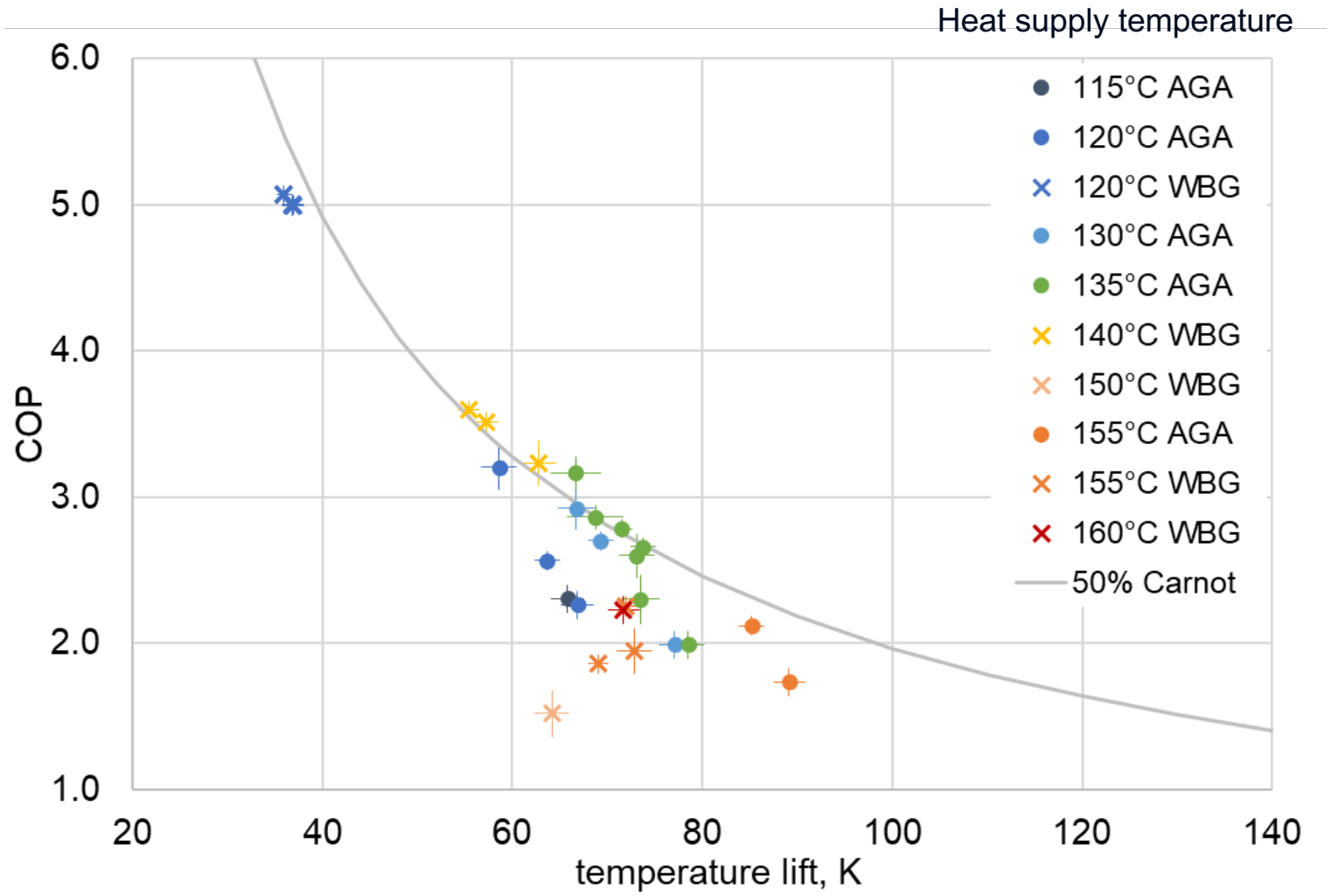
Integration infrastructure:

- pressure maintenance device
- water pump for the oil cooler
- flow measurement for the oil cooler
- pressurized air supply
- availability of the source and the sink

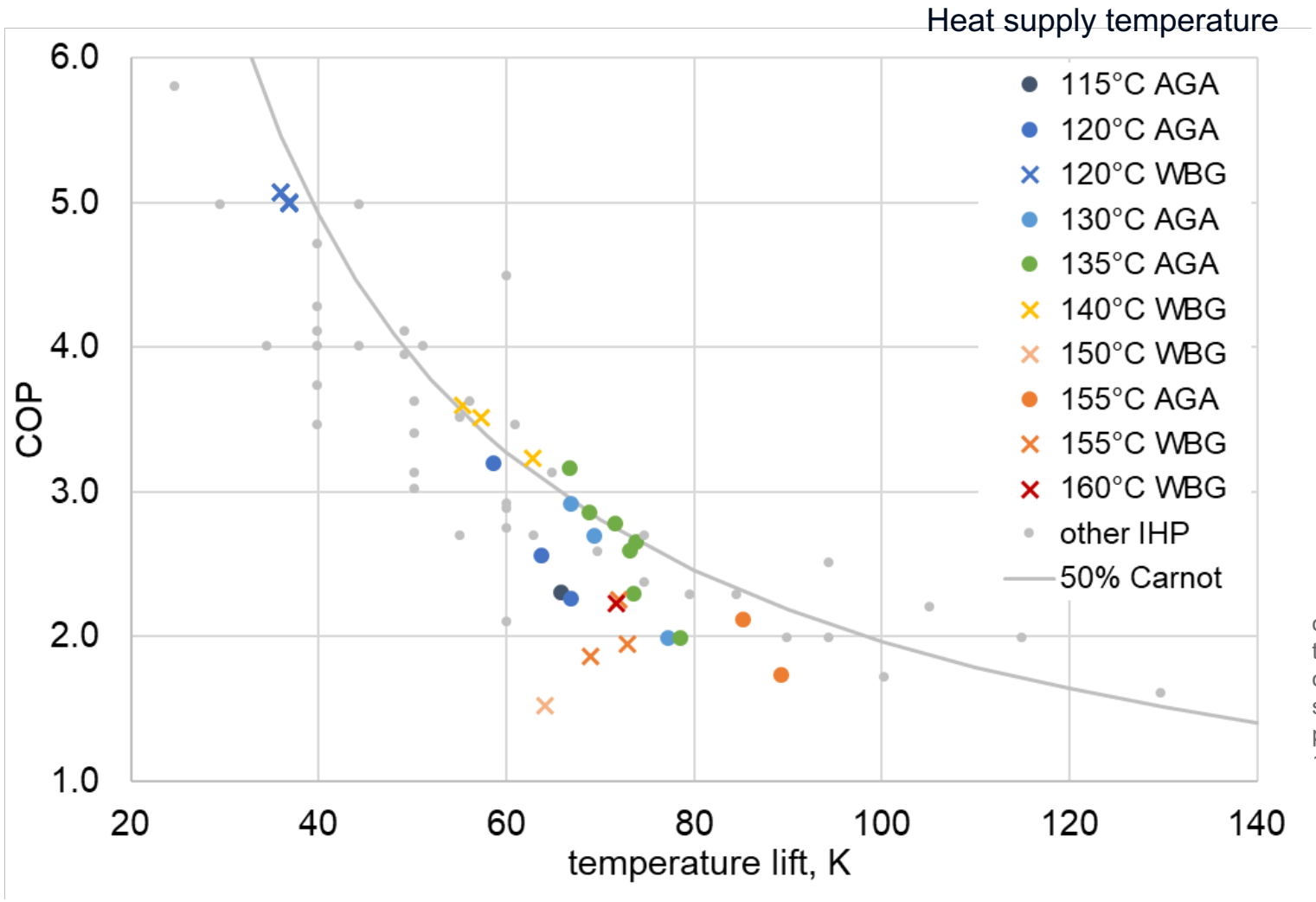
Process control

- start up procedure
- data transfer
- measurement devices

Overview on COP

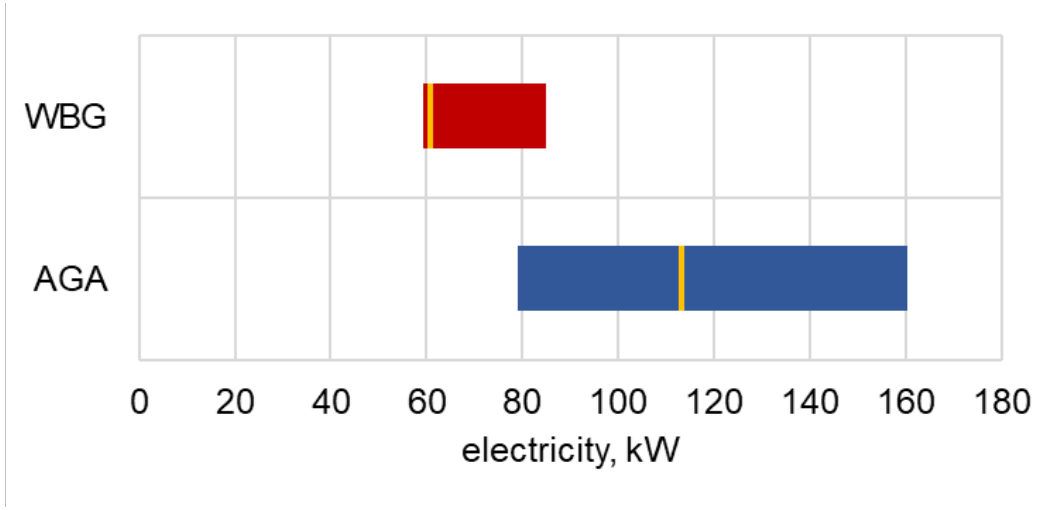


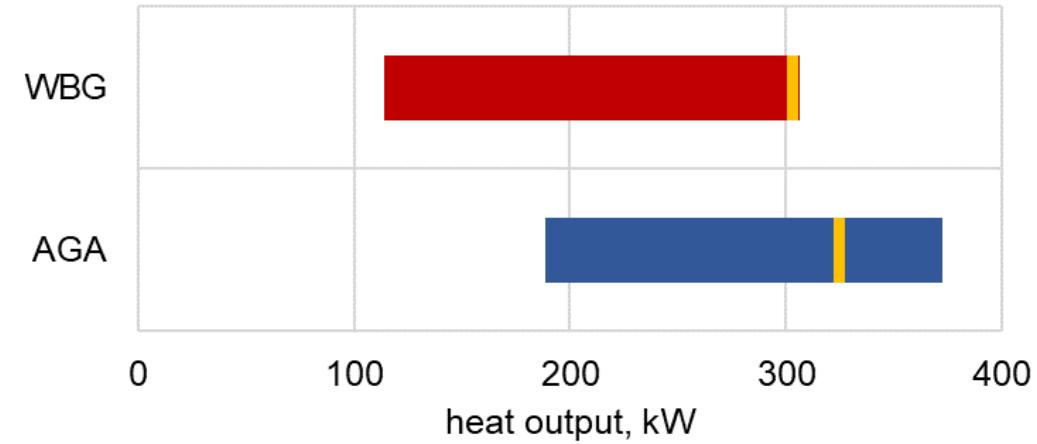
Overview on COP



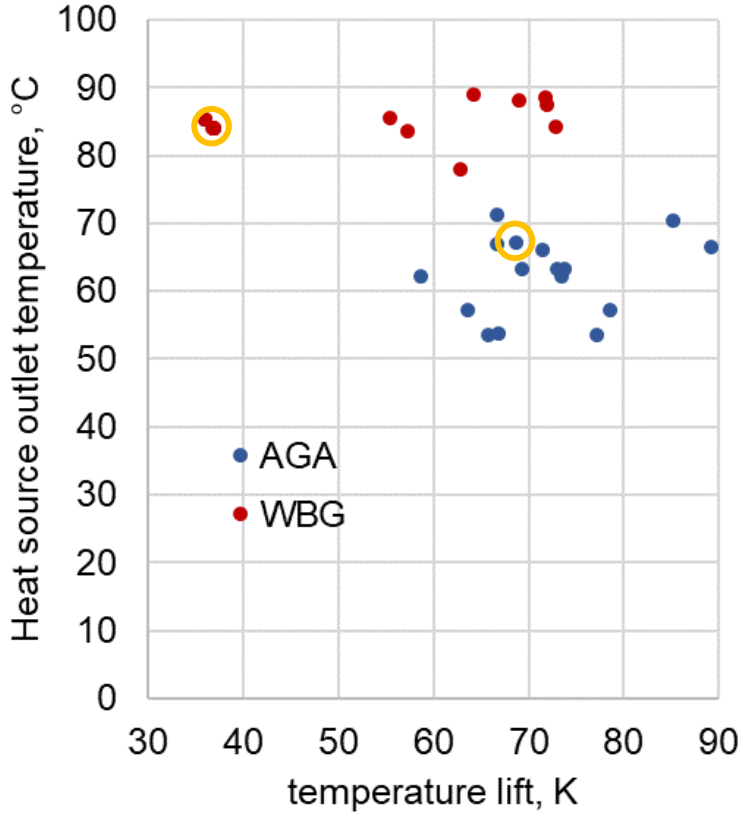
other IHP from Arpagaus et al. High temperature heat pumps: Market overview, state of the art, research status, refrigerants, and application potentials, Energy (152), p.985-1010, 2018.

Energy balance: input and output

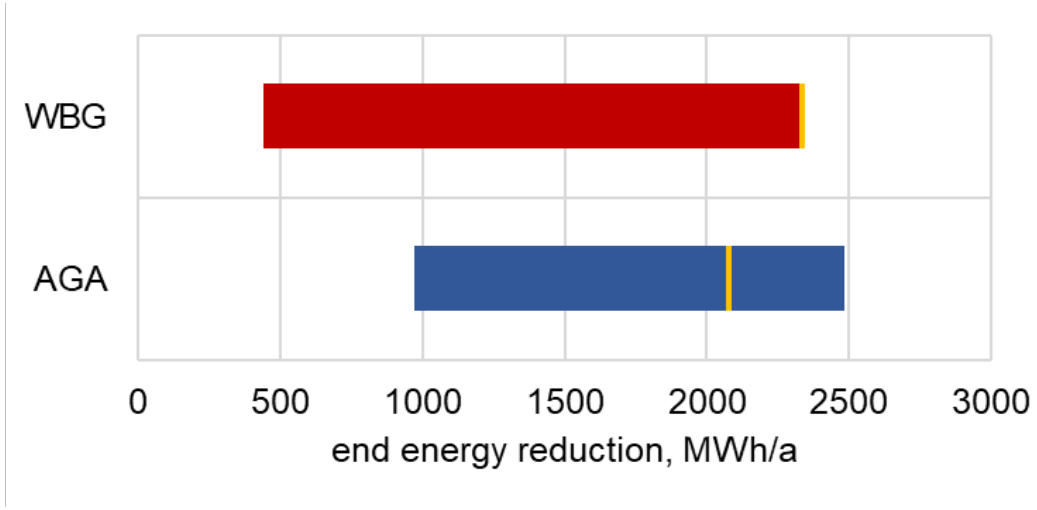


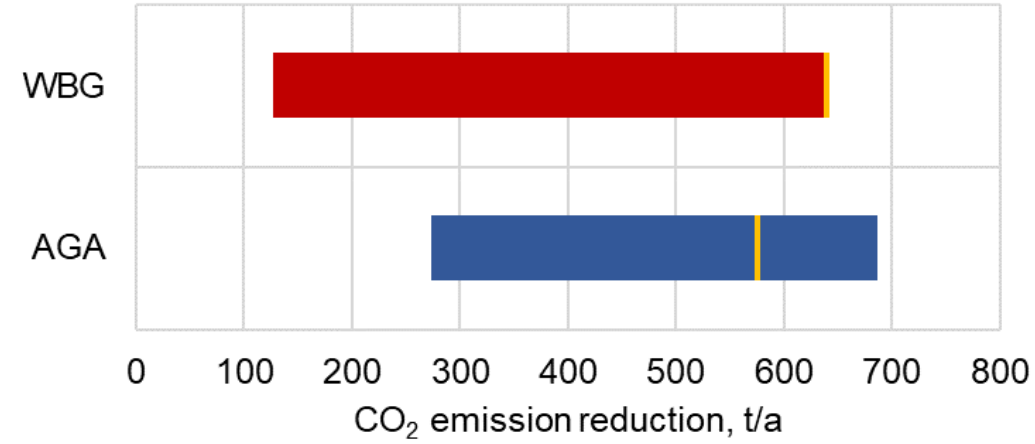


Design point: heat supply temperature of 120ºC (WBG) and 140ºC (AGA)



Environmental impact: End energy and CO_2 emission reduction



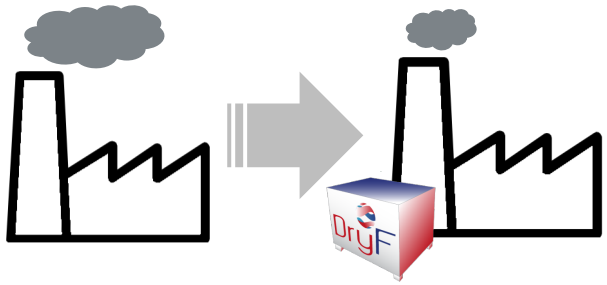


Comparison to a natural gas burner (90% efficiency, 8400 h/a)

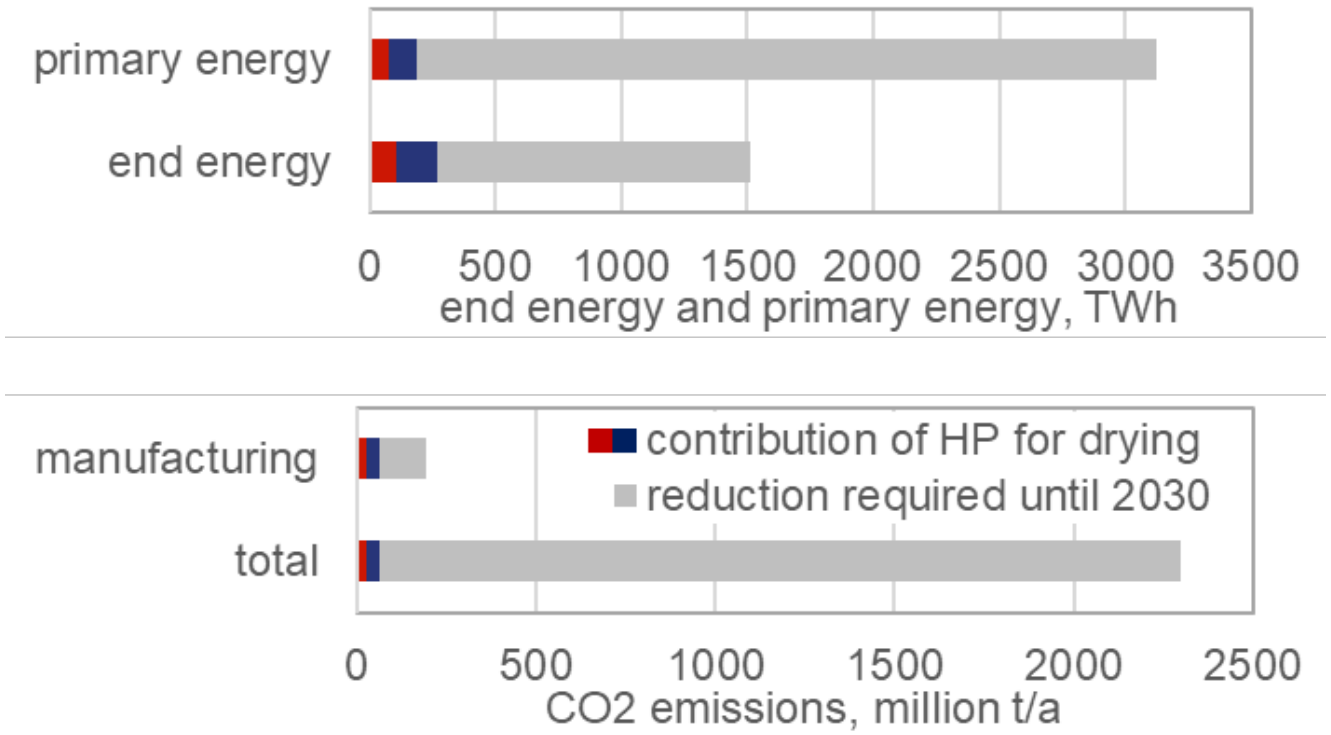
CO_2 emissions natural gas: 271 g/kWh

CO_2 emissions electricity: 258 g/kWh

Outlook



- assume that 50% of all drying processes in Europe are equipped with a DryFiciency heat pump
- replace natural gas burners
- impact on end energy consumption, primary energy and CO2 emissions



Summary

- Successful component development for high temperature applications
  - compressors, lubricant and refrigerant

- Successful demonstration of the closed loop heat pumps
  - stationary operation with satisfying performance
  - process control works well and balances variations in the heat source and sink
  - almost 7000 h operation hours achieved for both demonstrators until end of June

- Heat pumps are a future proof process heat supply technology
  - CO_2 emission reduction
  - waste heat recycling