

Joint EPS-SIF International School on Energy 2021

TRANSCRITICAL CO₂ HEAT PUMP equipped with energy storage systems

Chiara Mancinelli, Ph.D. student in Industrial Engineering



Research fields

- Energy efficiency and decarbonization
- Electrification of heating and cooling sectors
- Natural refrigerants
- Thermal Energy Storage
- Phase Change Materials (PCM)
- Dynamic modelling



Residential buildings
(Esp. Far Eastern market)

Case study: Dorin's facility,
Compiobbi (FI)

Costs

Low cost of electricity at night

Natural gas is much cheaper
(43 €/MWh_{th} vs ~130 €/MWh_{th})

Thermal Storage

Crucial

Load levelling

Thermal Users

Optimal ratio: DHW > 50% total
demand

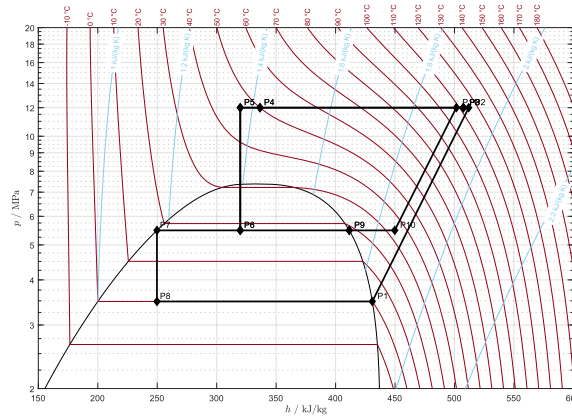
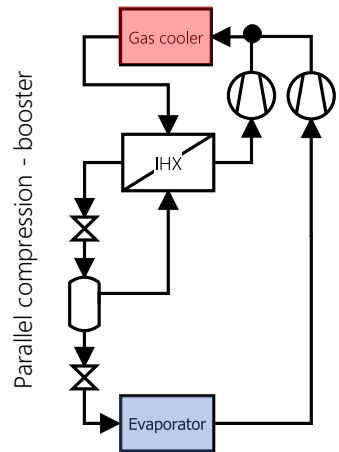
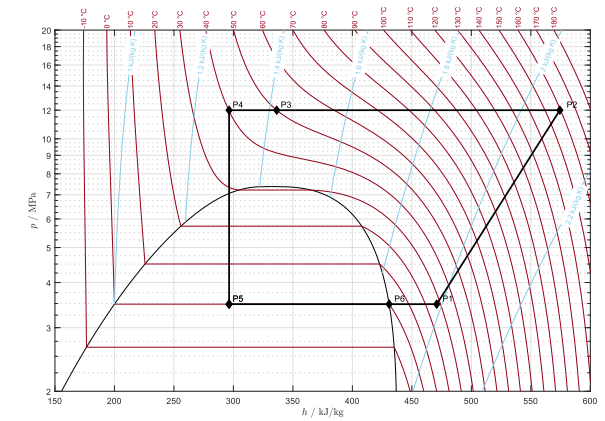
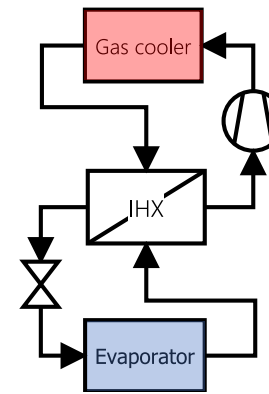
- DHW < 10% of total
- Process heat $T > 50^{\circ}\text{C}$
- Ambient heating $T > 30^{\circ}\text{C}$

Cold Users

Generation of cooling energy is
very convenient

Penalised due to the lacking of
low-temperature users

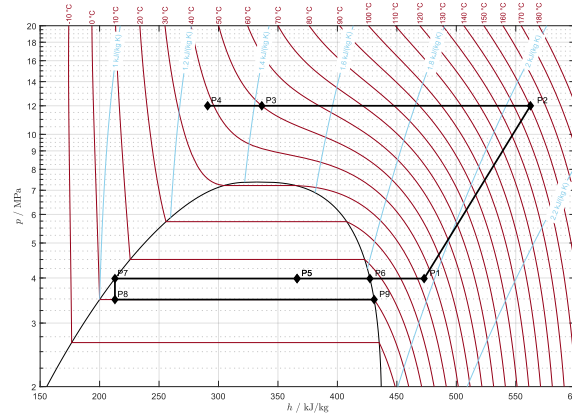
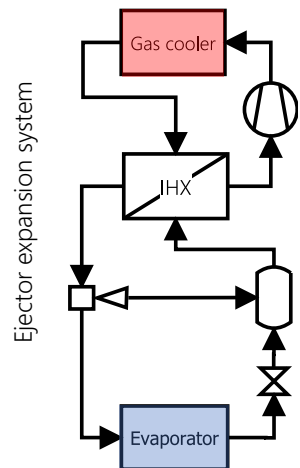
State of the art: preliminary comparisons of technologies



+ ~7 % COP

BUT

an additional
compressor is
required

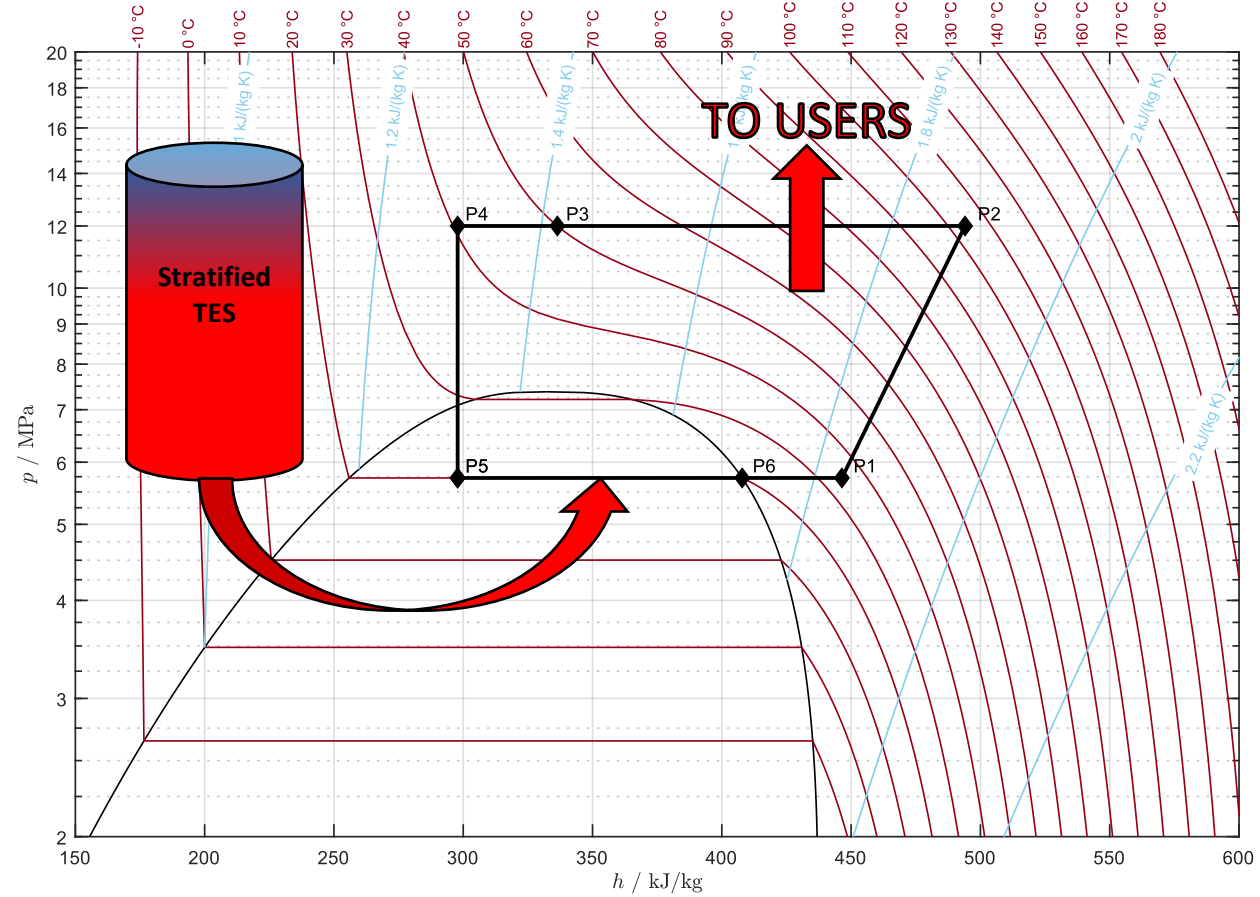
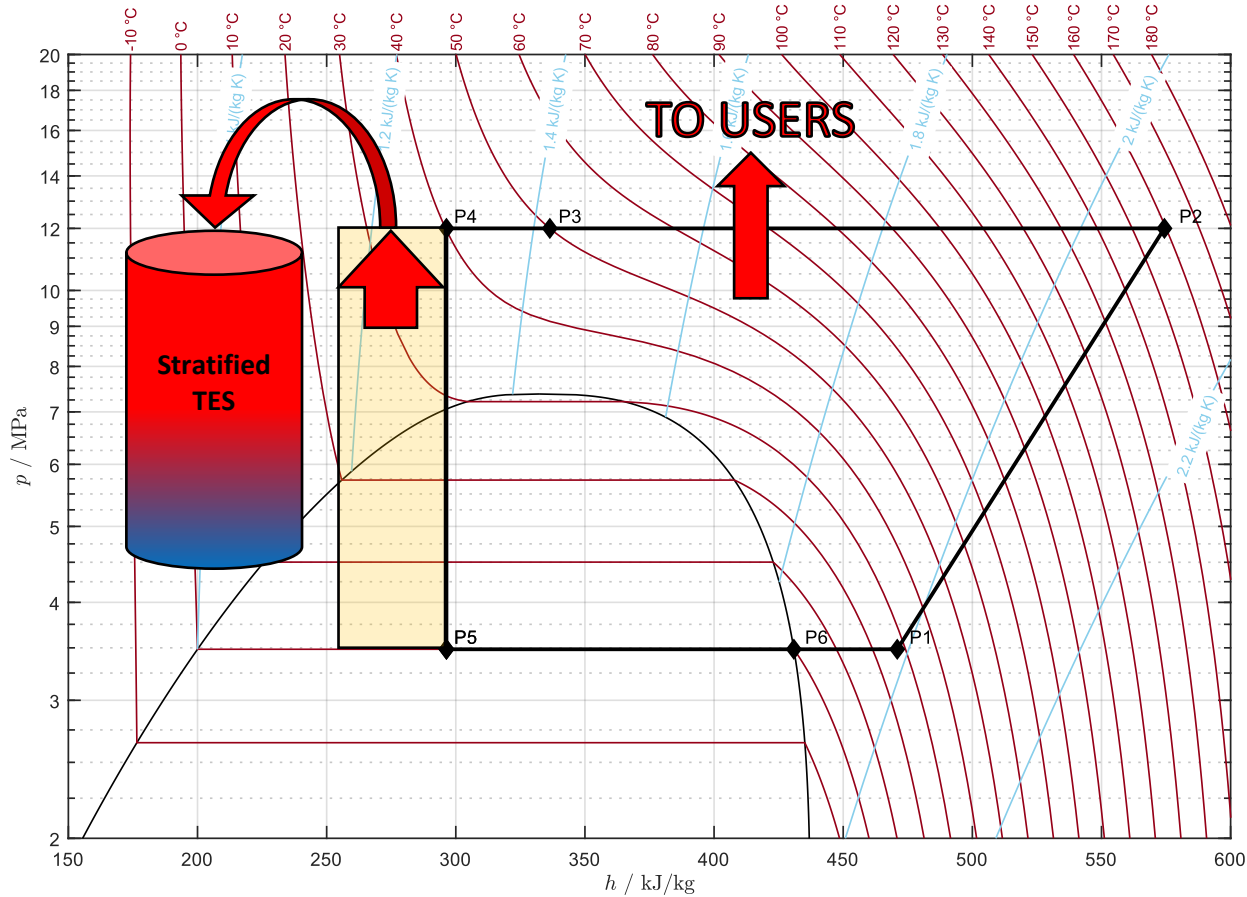


+ ~8 % COP

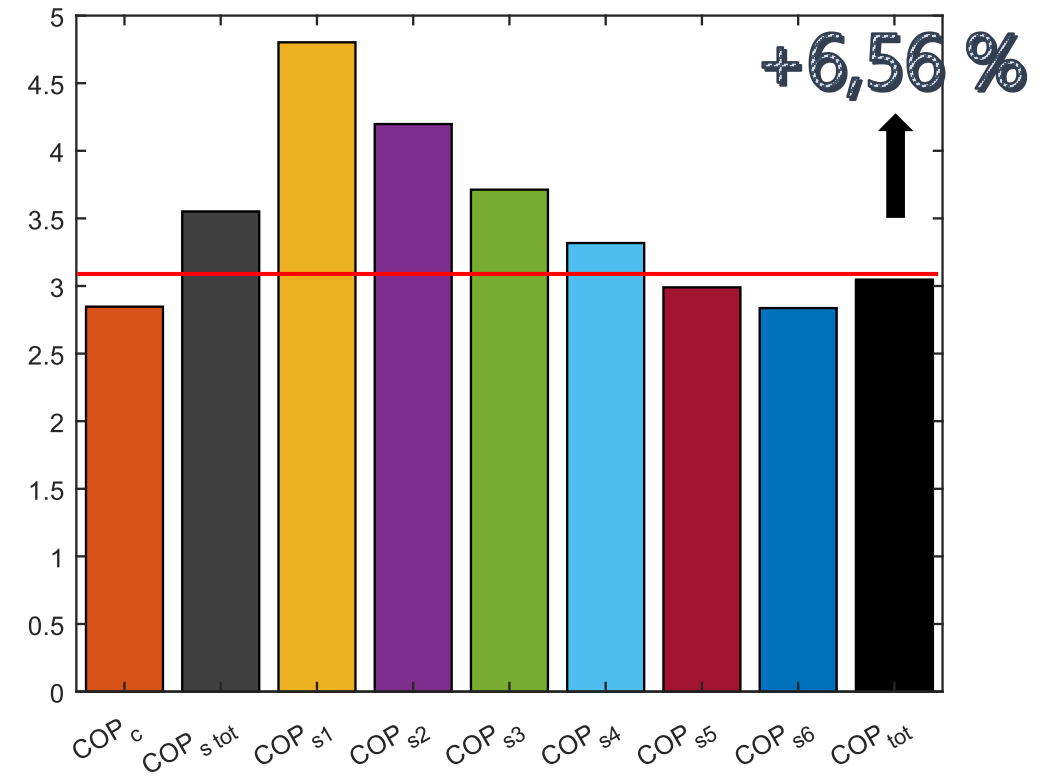
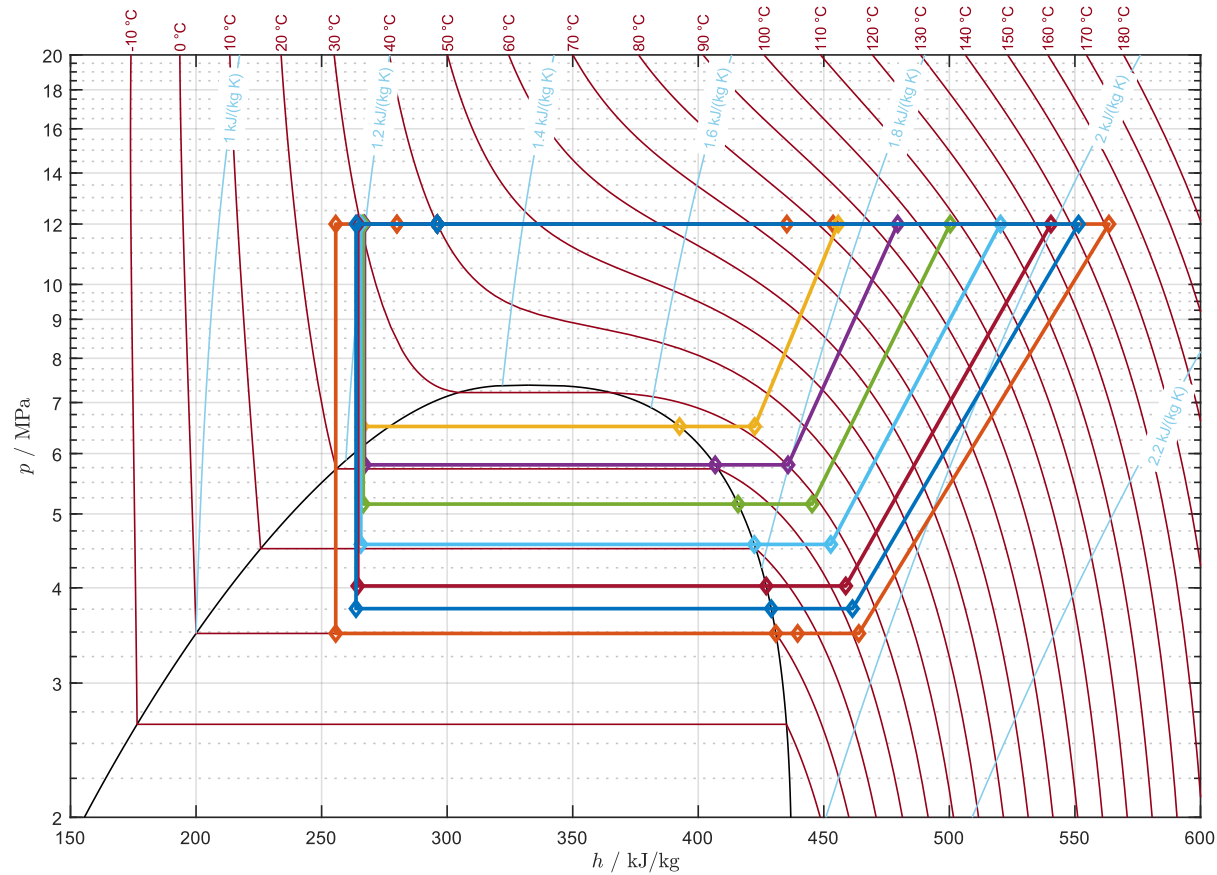
BUT

currently not
developed for very
high flow rates,
multiple ejectors in
parallel required

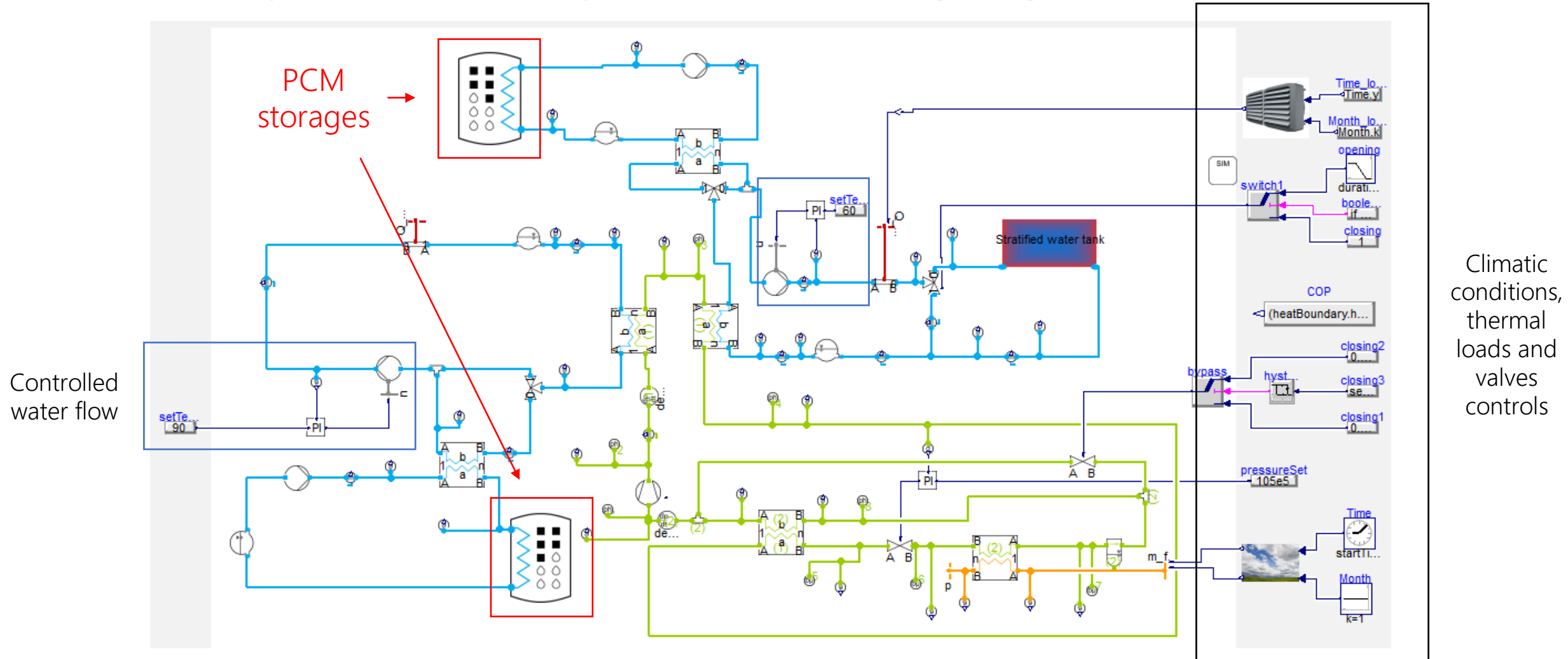
Can a TES be used as an alternative way to improve the COP?

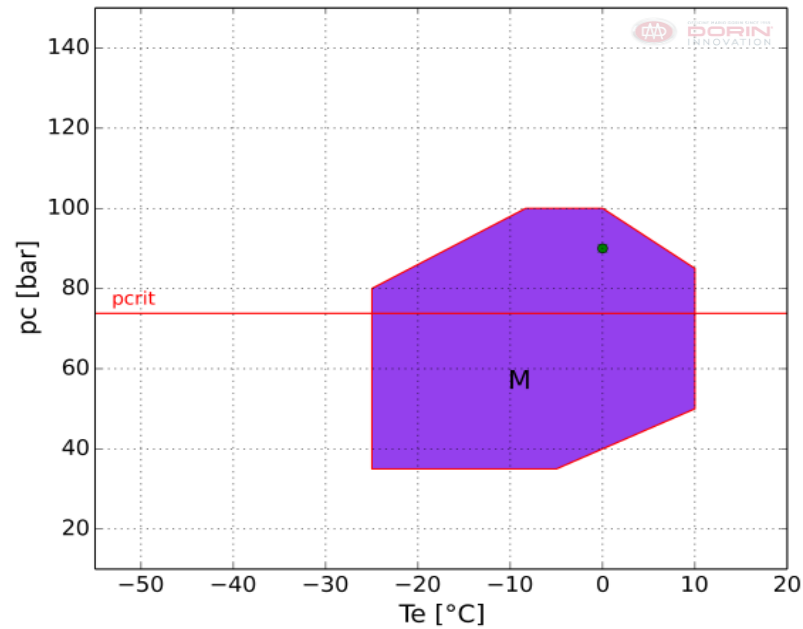


Discharging cycle → COP is improved



Pilot system in Dymola: charging scheme



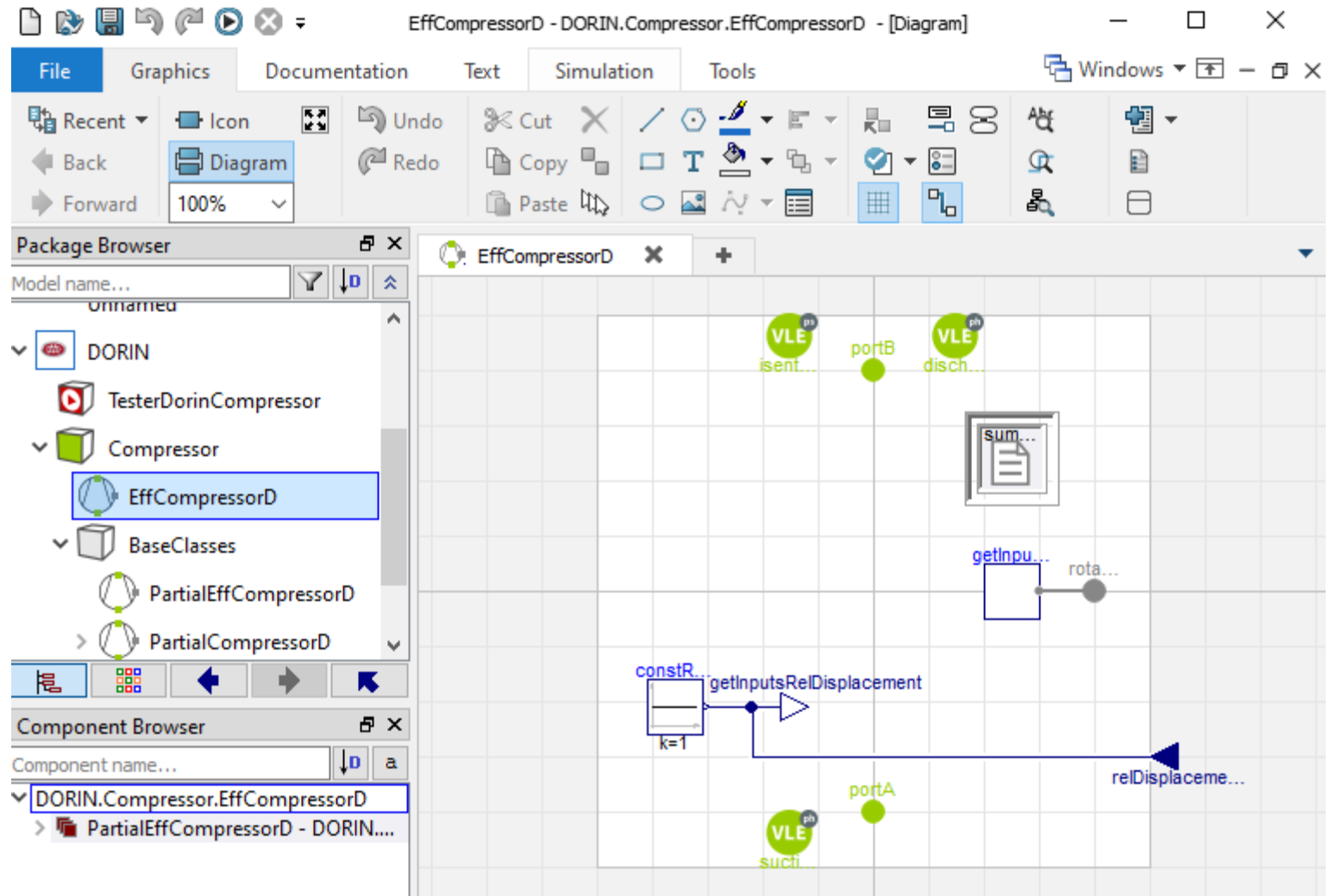


Continuously updated following
the actual design process

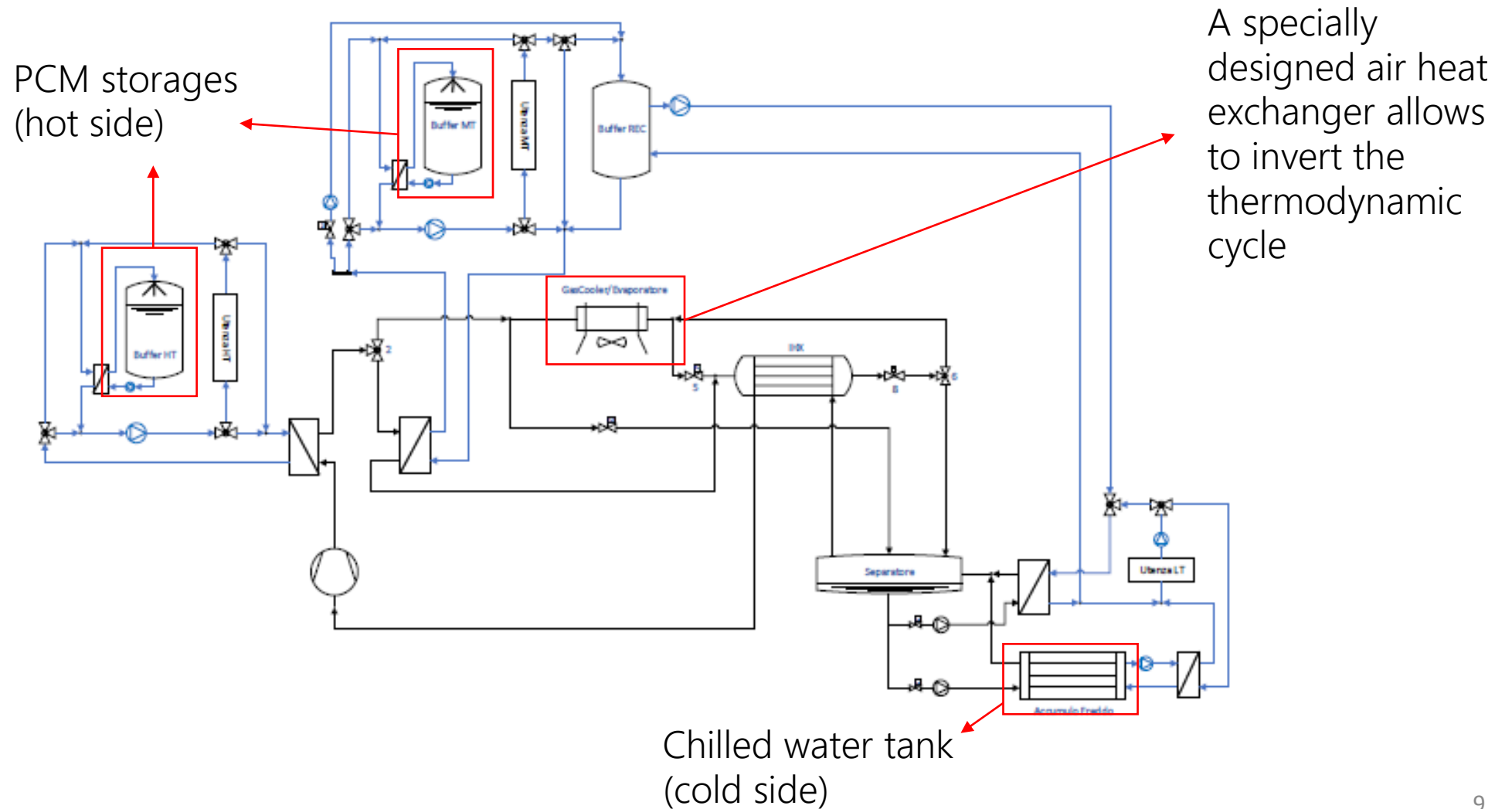


From 50 m³/h to 300 m³/h of the
final compressor

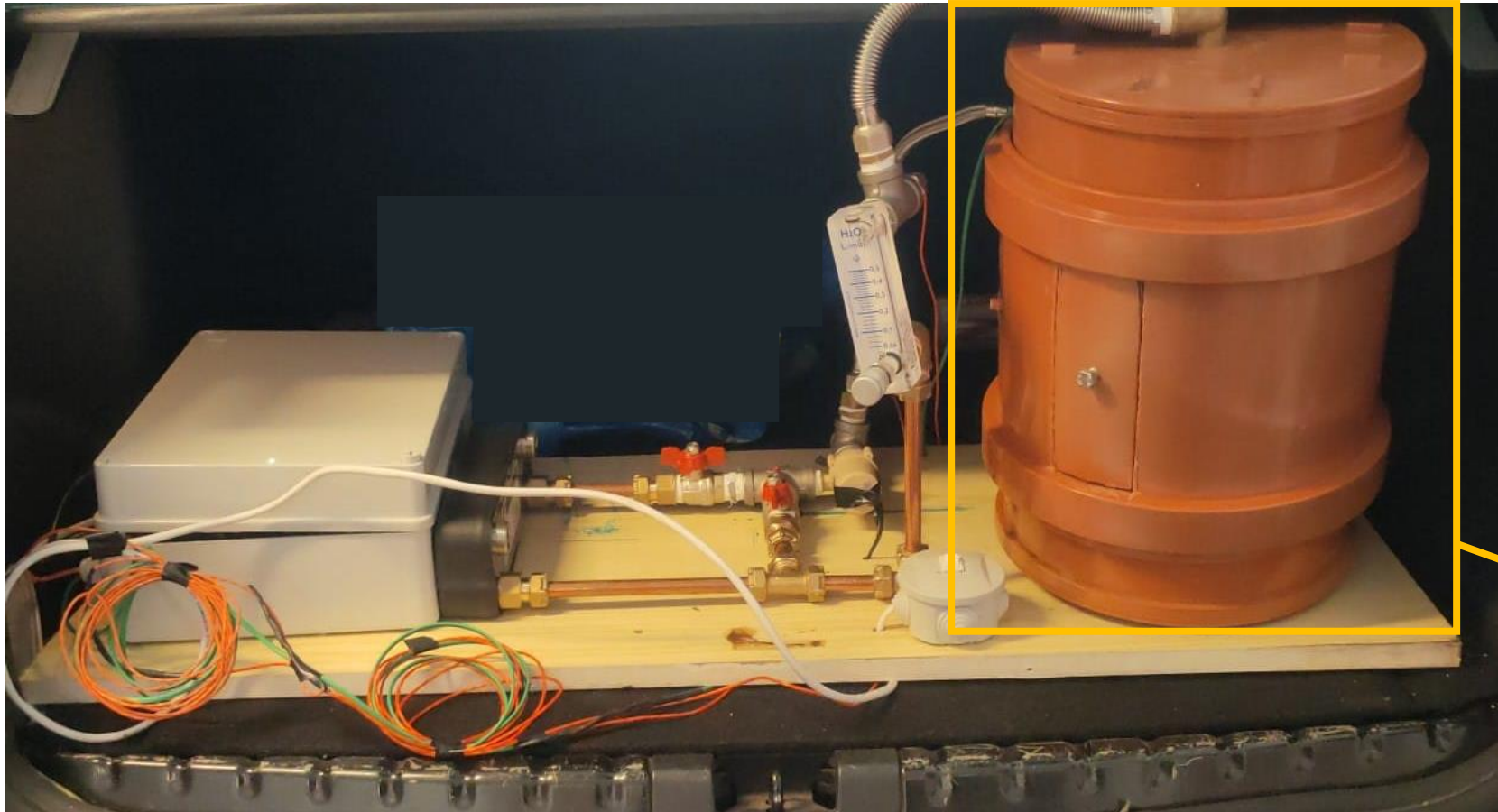
Compressor model is being built upon data from Dorin



Final layout



Testing PCMs..

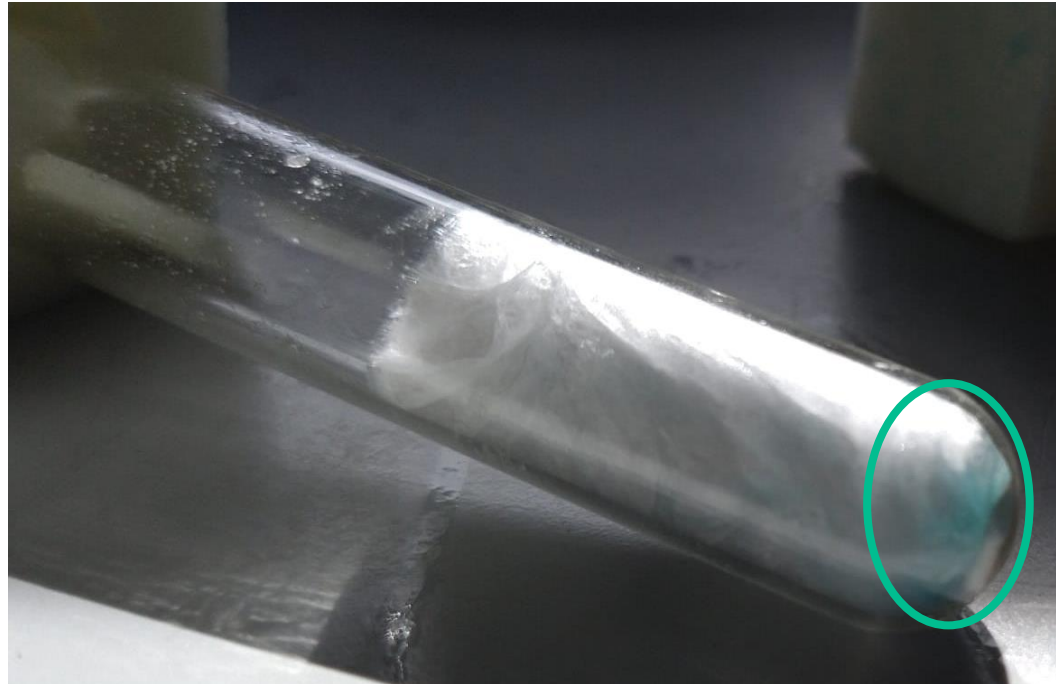


Direct contact
between PCM
and water in
order to
improve heat
exchange

..work in progress



Presence of oxide when copper is in contact with the PCM



Possible corrosion of brazed plate heat exchangers!!

Future activities

- Case study: actively participate in the next steps of the project including experimentation on the pilot system;
 - meanwhile modelling the pilot system in order to better understand the final demonstrator's behaviour.
- General case: study alternative applications of transcritical heat pumps with specific attention to civil/industrial users whose thermal and cooling needs differ from the case study;
 - implement a measurement and monitoring system, including an alternative way to measure vapour quality;
 - introduce an ejector expansion system and perhaps a multi-ejector scheme with management issues;

Thank you for your attention