

Performance and safety analysis of charge reduced brine to water heat pumps using R290

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The Project



BDR THERMEA GROUP



BOSCH
Invented for life



ferroli

KERMI

REGLI
ENERGY SYSTEMS

STIEBEL ELTRON

VAILLANT GROUP

Viessmann

Steering Committee, definition of requirements, receipt of results and access to IPs

1,2 Mio. € (approx. 1-4 % of total project volume, pro rata market share)



3,6 Mio. €
(75 % funding rate)
FKZ 03EN4001A



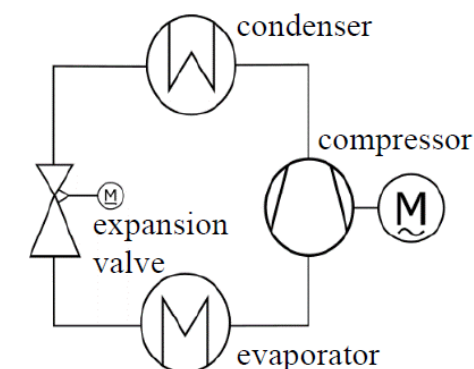
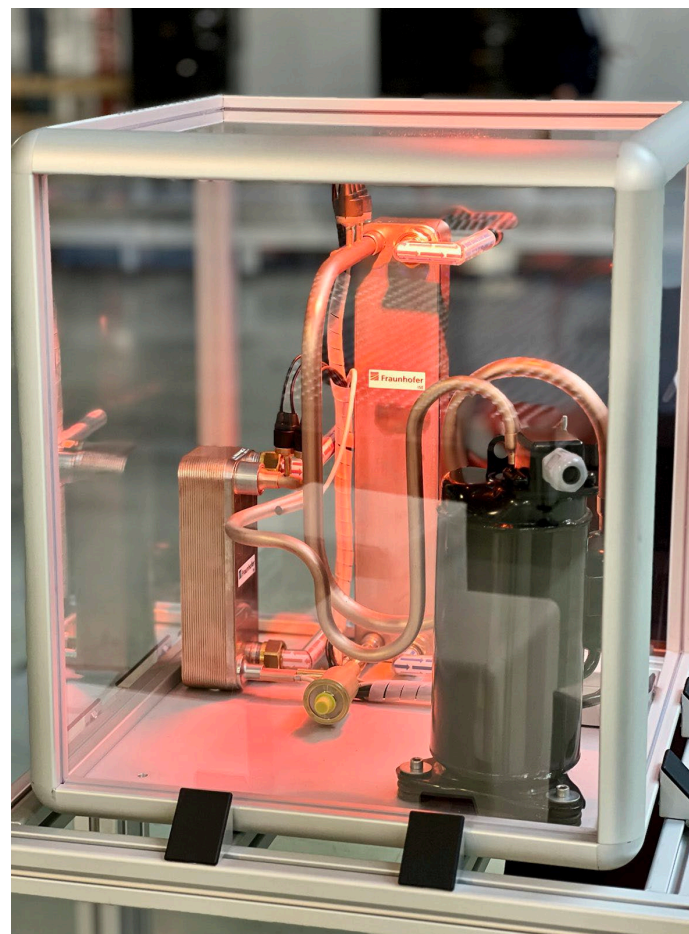
LC150 PLATFORM DEVELOPMENT OF A CHARGE-REDUCED HEAT PUMP MODULE WITH PROPANE

4,8 Mio. € project budget, 2.75 years, 1.10.2020 – 30.06.2023

- Component testing (heat exchangers, compressors, valves etc.) in single component tests and in broad cross evaluation
- Charge reduction and localization of refrigerant
- Operating strategies
- Standardization
- Network and platform for manufacturers

Prototypes and test environment

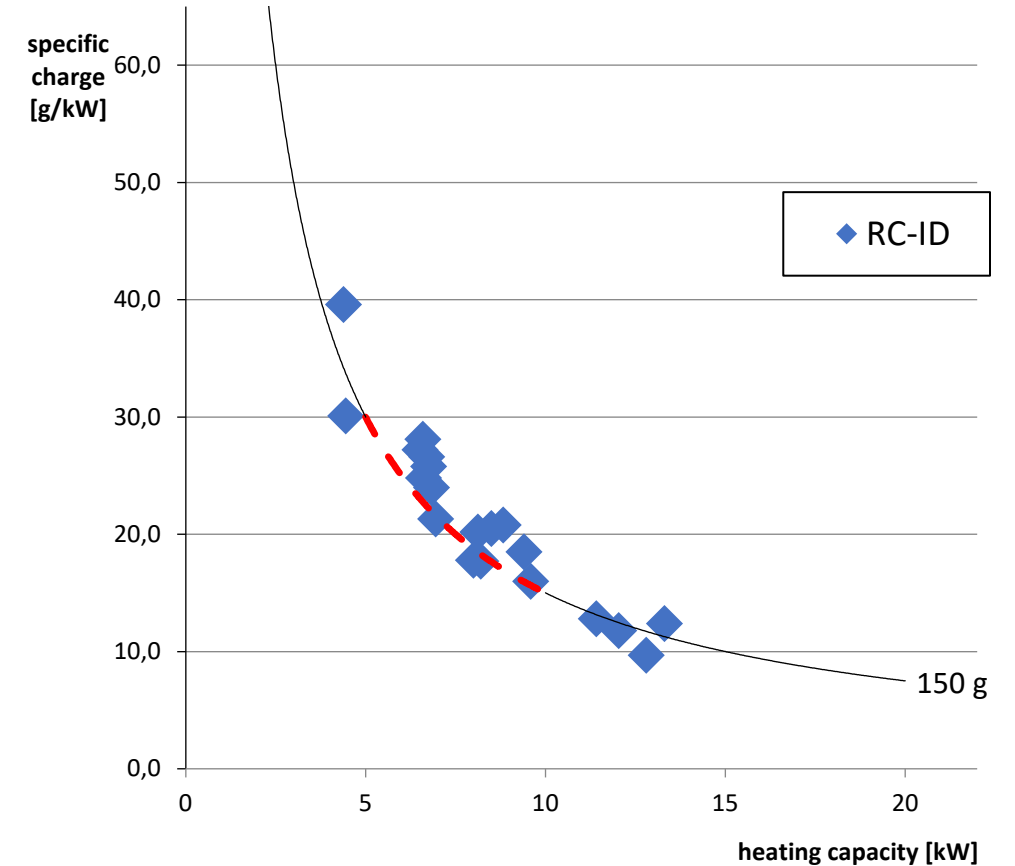
- Main components
 - Compressor
 - Evaporator
 - Condenser
 - EEV
- Short tubing
- Reduced oil charge
- No 4-way valve
- No accumulator
- No filter dryer
- No internal heat exchanger



Results overview

- 23 successful refrigerant circuits measured
 - Min charge possible to max charge
 - Min optimal charge plotted @B0/W35/F60/SSH10
 - 10 different condensers
 - 9 different evaporators
 - 4 different compressors
 - Circuits are built with many different combinations
 - Automated charging $\pm 0.3\text{g}$ charge accuracy

General behavior extremely repeatable



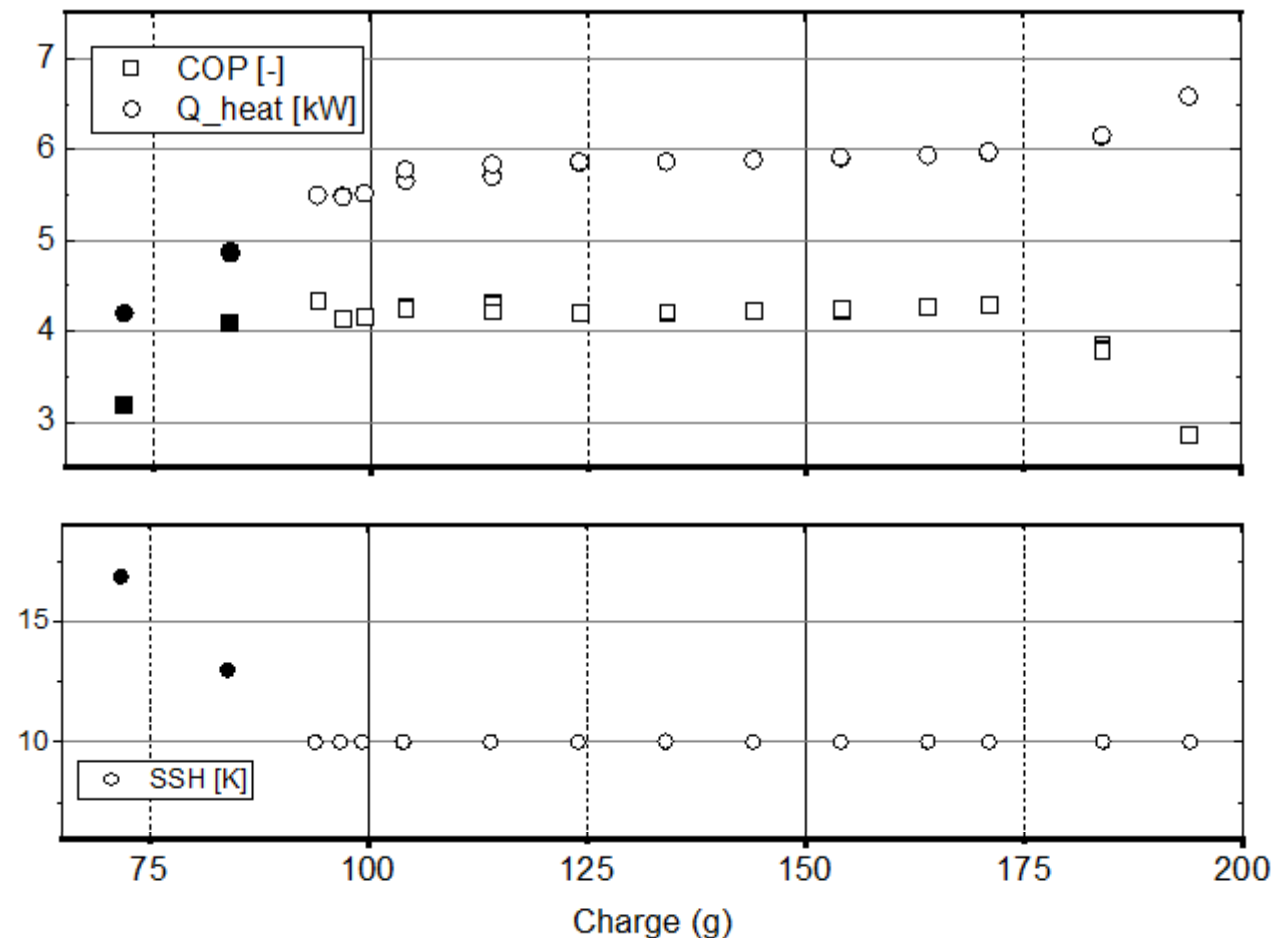
Performance over charge

COP heat cap on this slide

Next more

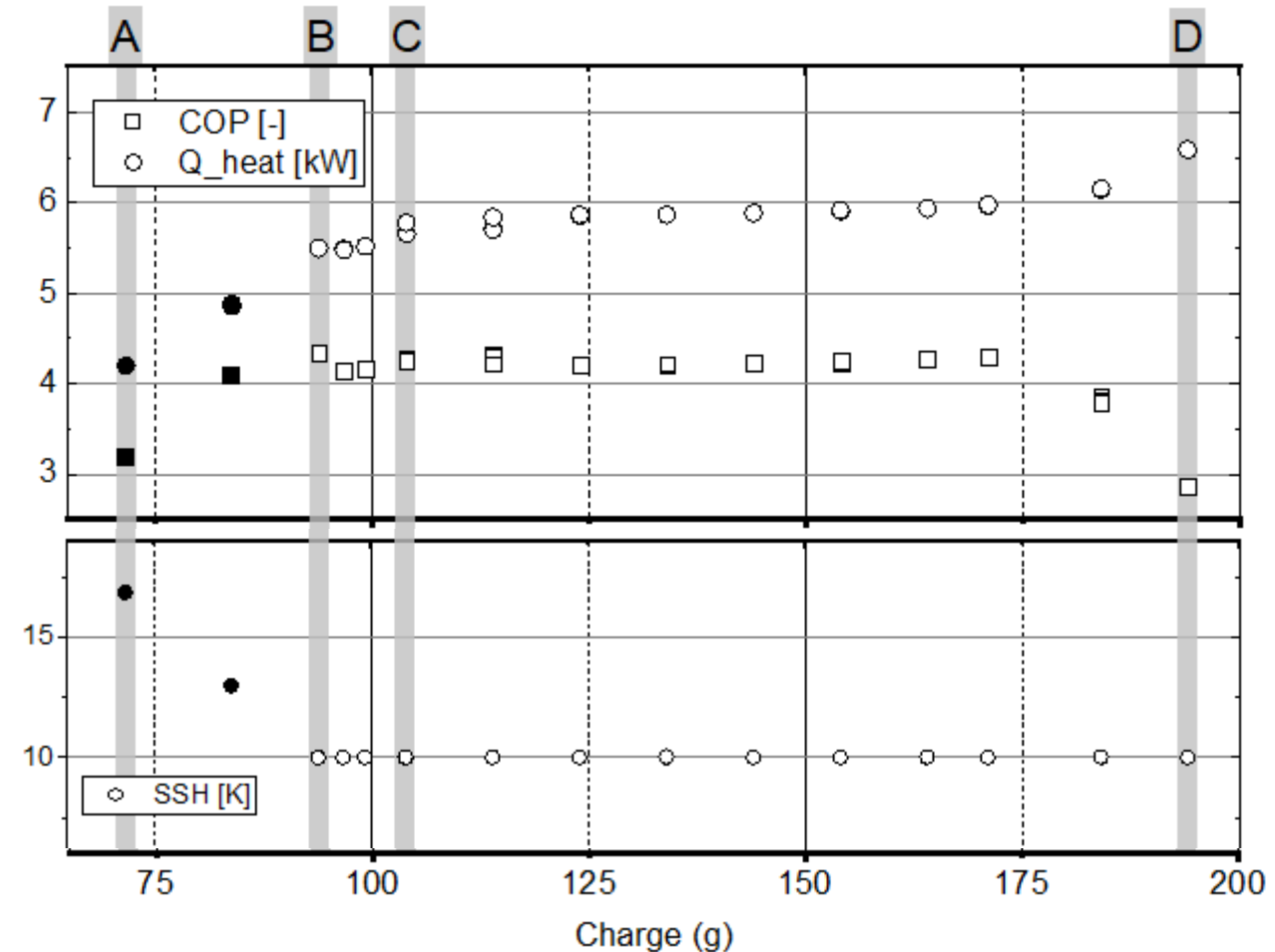
Dann erst aufteilung

- All measurements are steady state @B0/W35/F60/SSH10
- ~10g interval between measurements
- Low charge measurements don't have SSH 10K



Performance over charge

- All measurements are steady state @B0/W35/F60/SSH10
- ~10g interval between measurements
- Low charge measurements don't have SSH 10K
- Four distinct operation states identified, and identification values defined



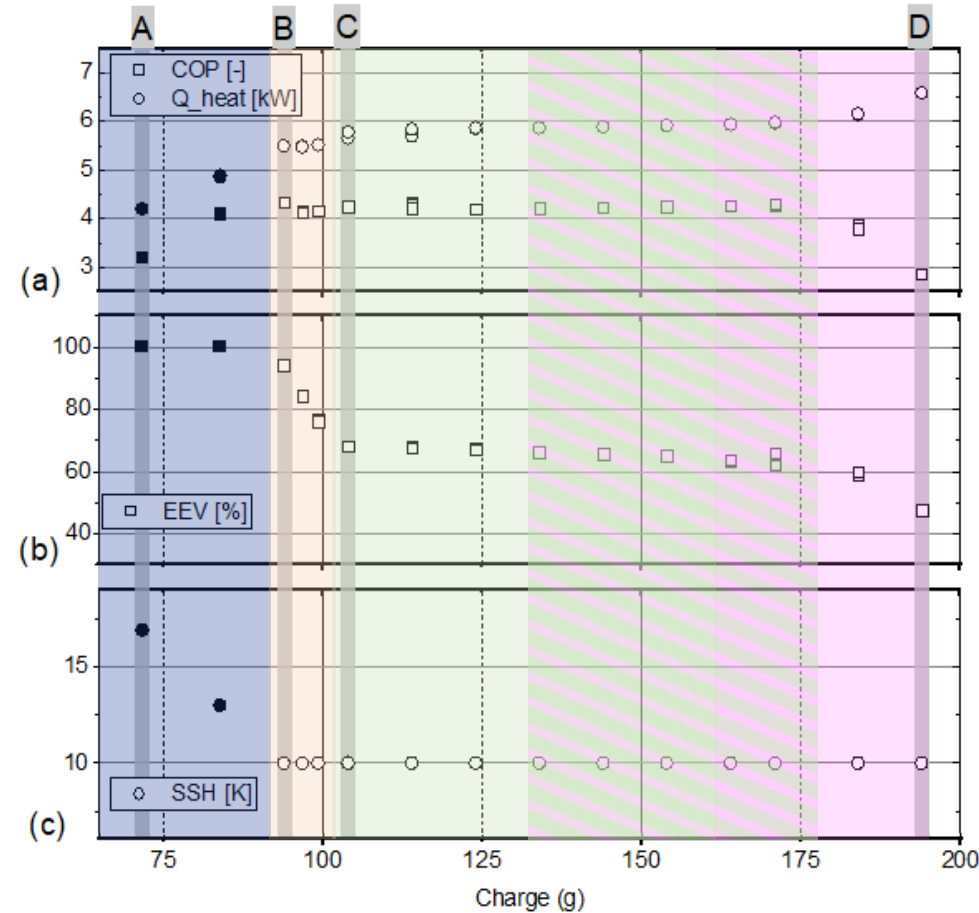
Performance over charge

■ [A,B] = extremely undercharged

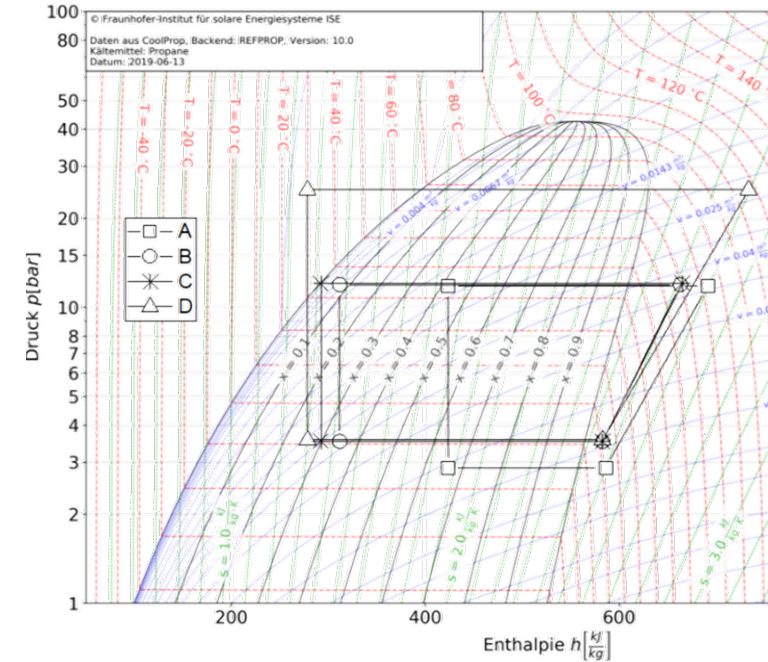
- EEV 100% open
- SSH larger than desired value
- Lower heat capacity
- reduced COP

■ [B,C] = undercharged

- EEV charge sensitive
- SSH as desired
- Lower heat capacity
- reduced COP

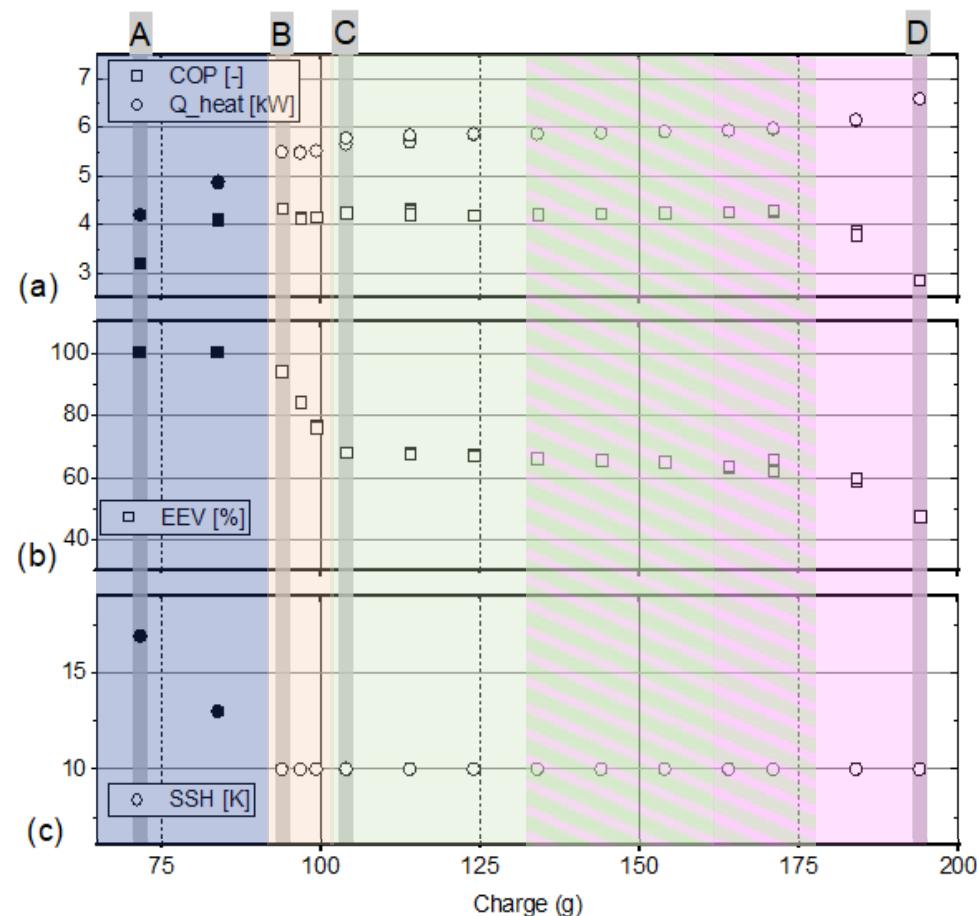


RC8-21 @B0/W35/F60/SSH10

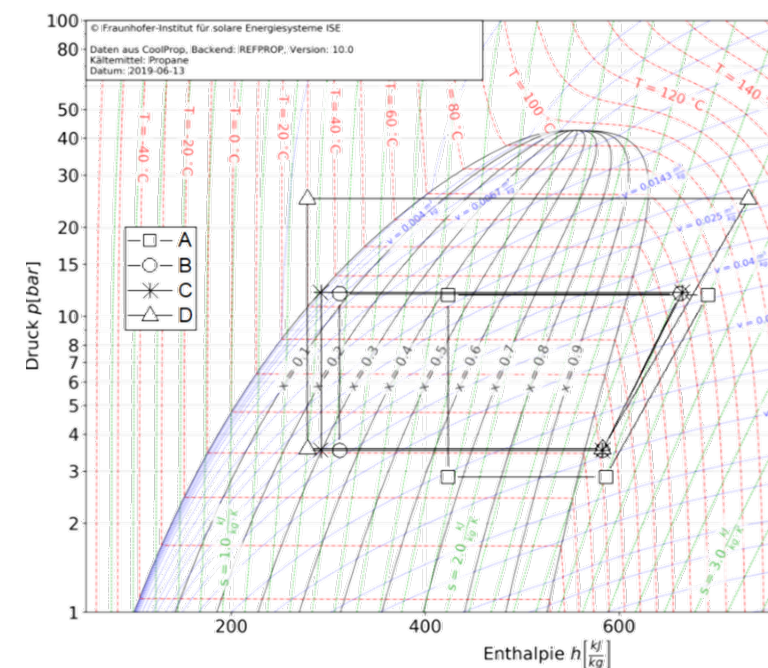


Performance over charge

- **C** = min. optimal charge
- **$[C, \sim D]$** = correct charge
 - EEV not charge sensitive
 - SSH as desired
 - Expected heat capacity
 - Expected COP
- **$(\sim D, D]$** = overcharged
 - EEV charge sensitive
 - SSH as desired
 - Higher heat capacity
 - reduced COP

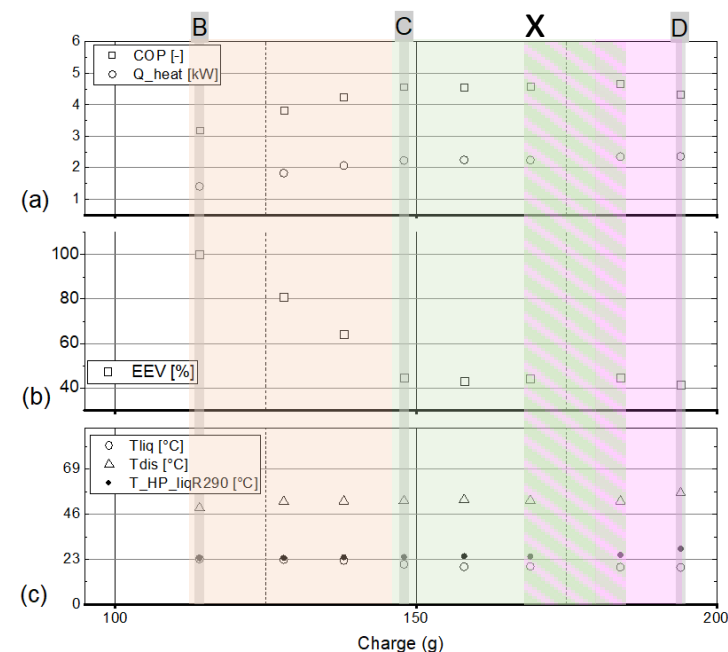
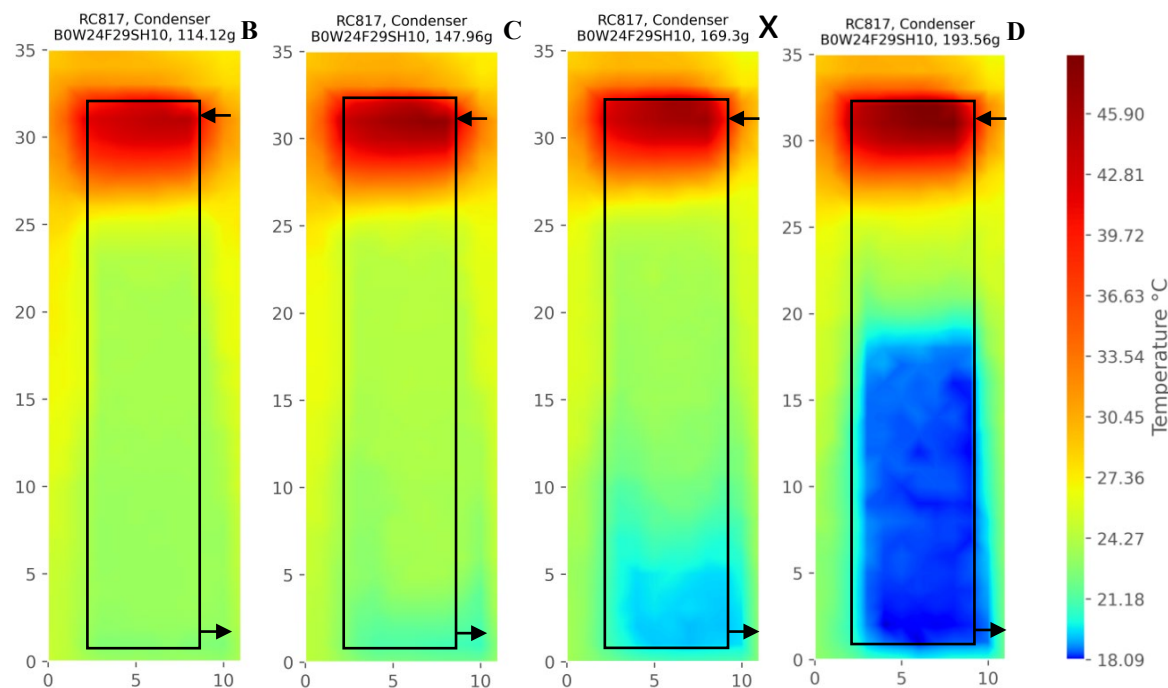


RC8-21 @ B0/W35/F60/SSH10



- B = no liquid are distinguishable
- C = slight sub cool implied

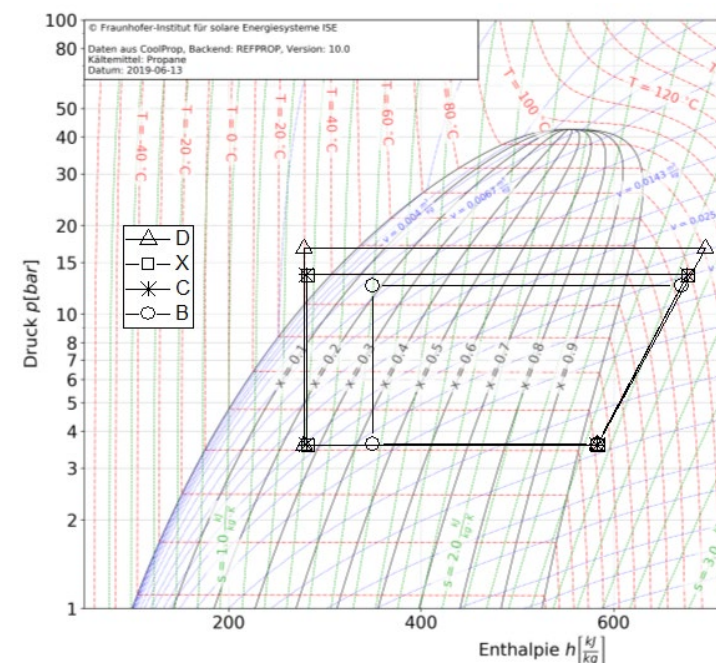
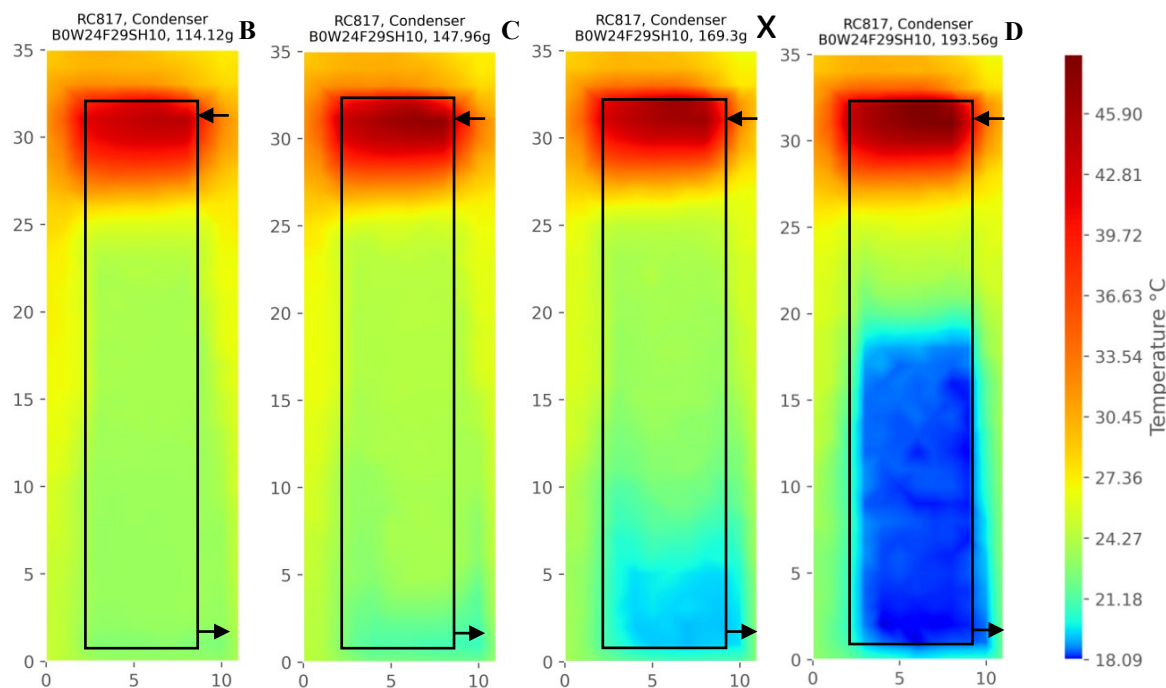
- X = noticeable sub cool
- D = >50% vol. filled with liquid R290 reduced area available for heat transfer



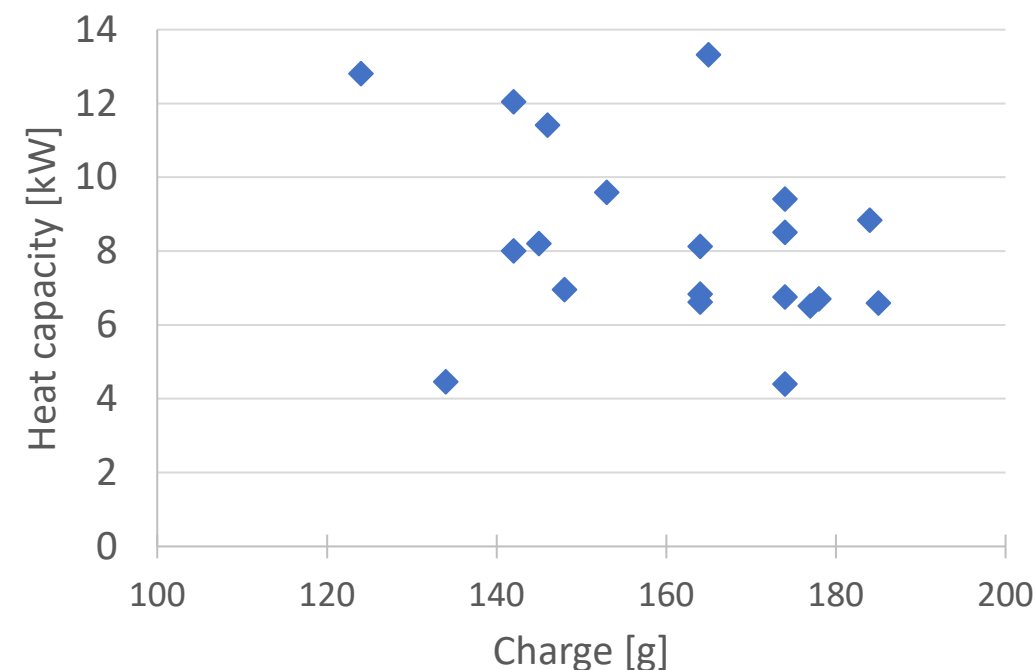
RC8-17 @B0/W24/F29/SSH10

- B = no liquid are distinguishable
- C = slight sub cool implied

- X = noticeable sub cool
- D = >50% vol. filled with liquid R290 reduced area available for heat transfer

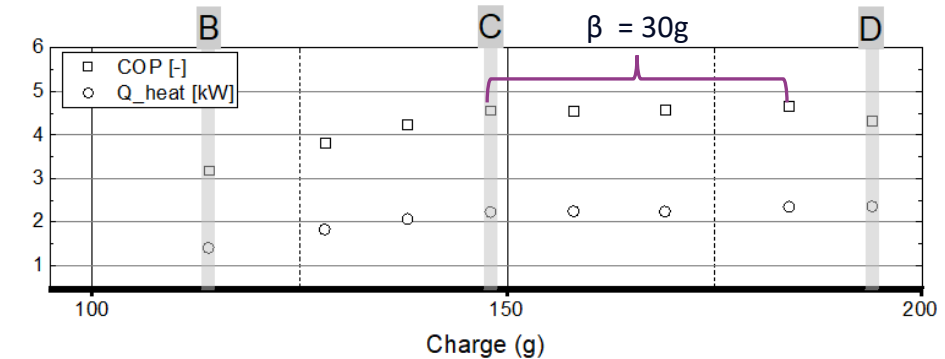


- All circuits <200g min. opt. charge @B0/W35/F60/SSH10
- Oil reduction -> 9-18%mass. R290 in oil
- Short tubes
- Small heat exchangers
- Small heat exchanger ports
- Filter dryer moved to suction line /removed
- Compressor insulation
- Super heat trade off efficiency vs. charge

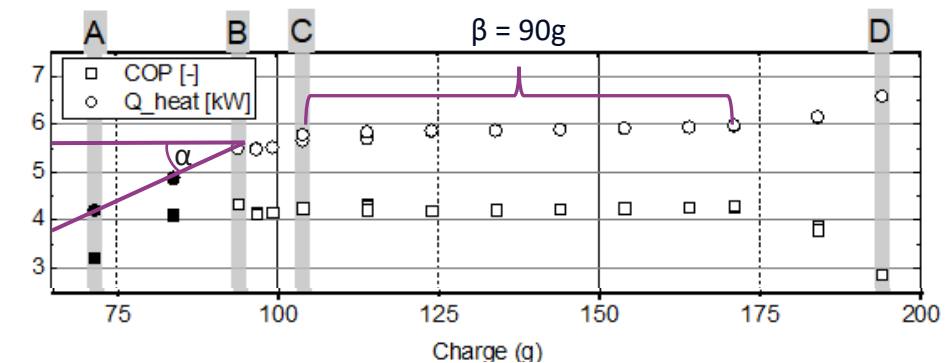


Summary and further work

- Good consistency of correlation shown
 - Theoretical correlation of measurements matches IR images
 - Summary of possible design changes/rules to reduce charge
-
- All the ranges can be evaluated, for example α or β
 - Potential volume correlations can be drawn based on the different angle of alpha or the width of beta
 - Additional information can be taken from IR images
 - Results build base for follow up project **LCR290**



RC8-17 heat capacity and COP over charge



RC8-21 heat capacity and COP over charge



Thank you for you attention

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