EVALUATION OF A LOW CHARGE HEAT PUMP CIRCUIT USING PROPANE

13th IEA Heat Pump Conference "Heat Pumps - Mission for the Green World", 26.-29.04.2021

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Fraunhofer Institute for Solar Energy Systems ISE

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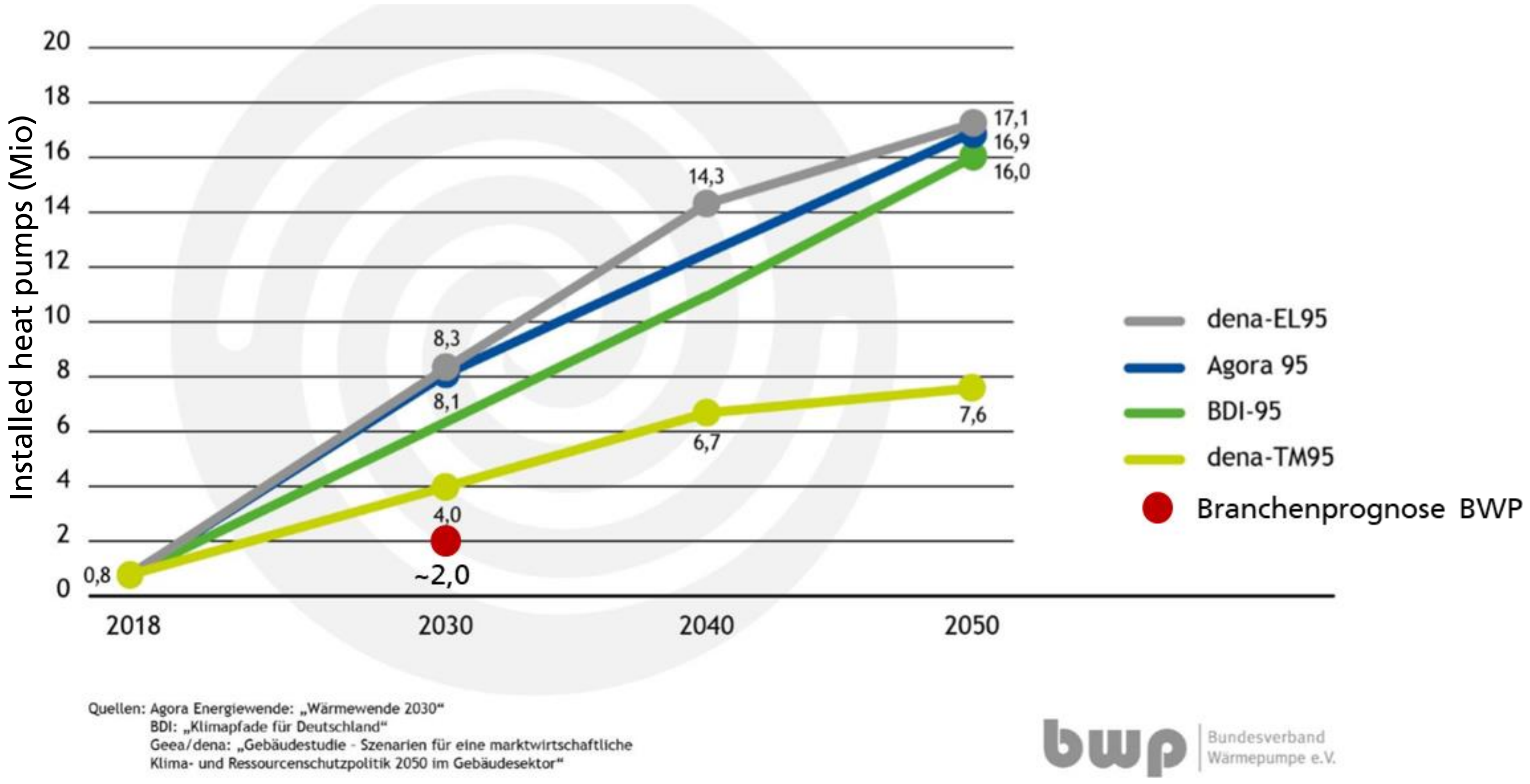
Low Charge Heat Pump Module using 150g of R-290

Motivation

- Heat pumps are the central heating technology for a climate-friendly future and decarbonized heating supply
- The market share has to be increased drastically in order to reach the needed reductions in CO_2 emissions
- New refrigerant solutions are needed due to F-Gas-Regulation



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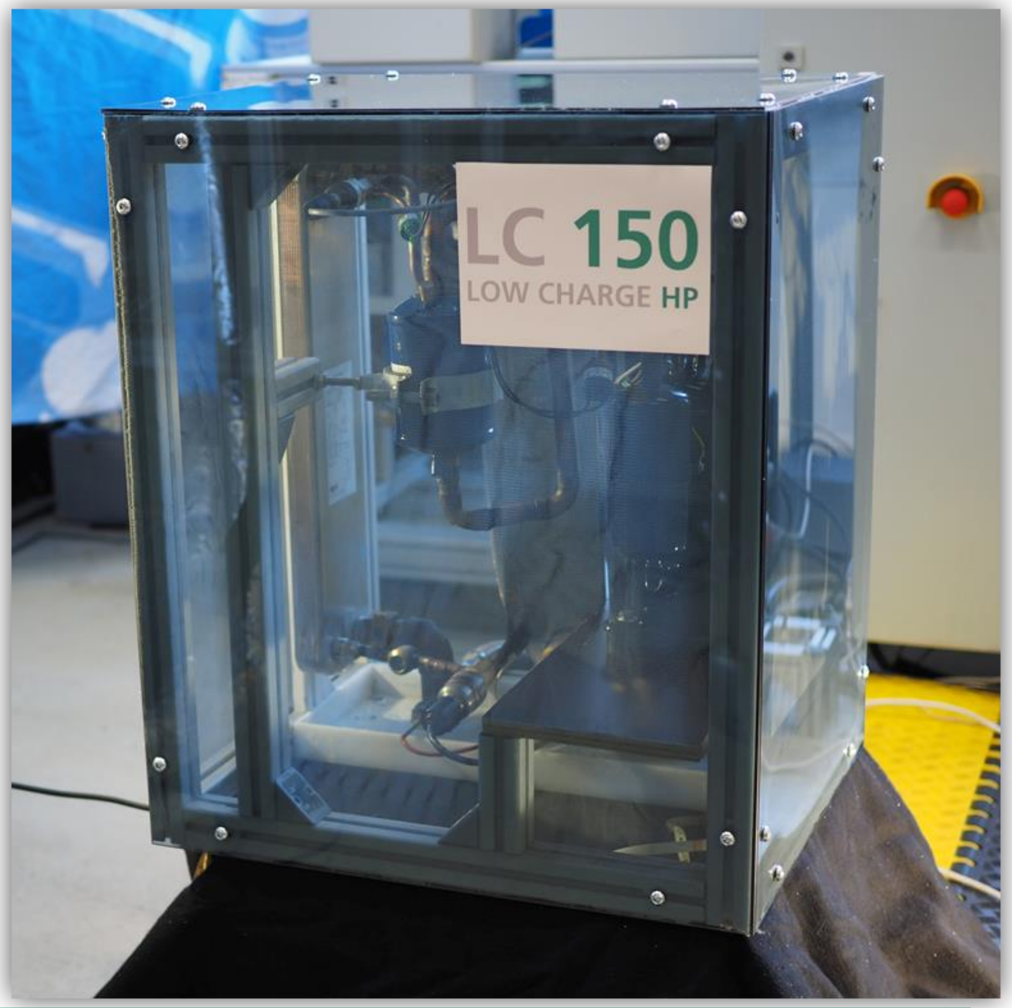
Low Charge Heat Pump Module using 150g of R-290

Goals

Goals of the feasibility study (10/18 – 09/20)

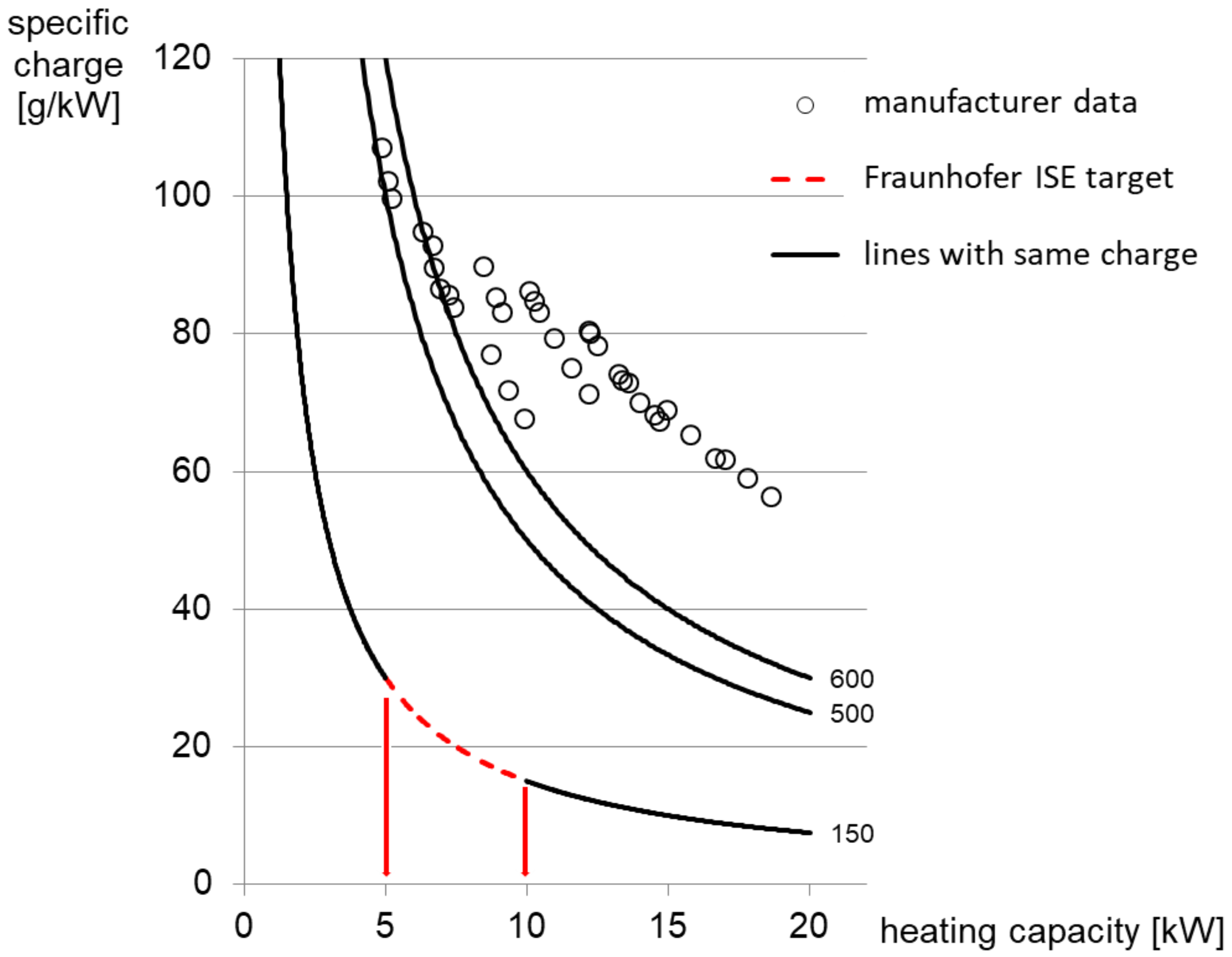
- Use of propane (R290) as refrigerant
- Providing a heating capacity between 5-10kW
- Use of market available components only
- Brine to water heat pump



Low Charge Heat Pump Module using 150g of R-290

Goals

- Market available brine-to-water heat pumps systems use 60-100 g/kW of refrigerant charge
- 150 g of refrigerant for 5-10 kW heating capacity corresponds to ~20 g/kW



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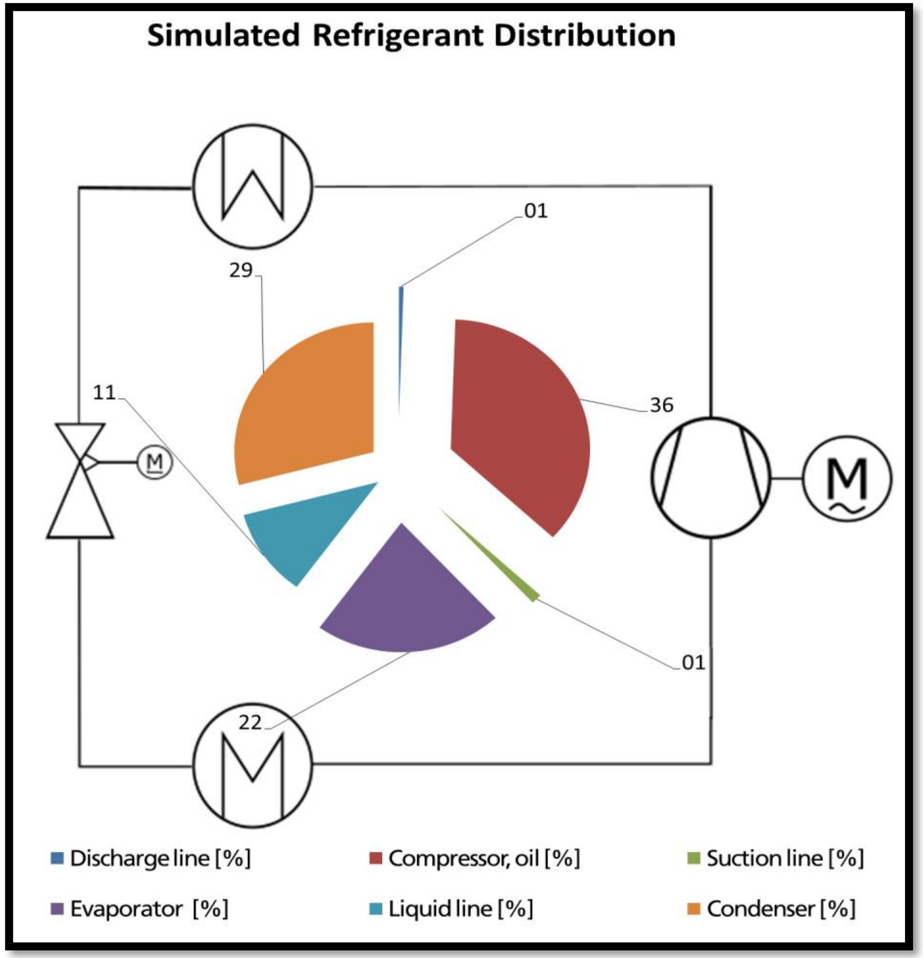
Design of the heat pump module

Addressing the parts with high refrigerant content

- Reduced volume due to asymmetric plate heat exchangers
- Reduced diameter and length of piping
- Reduced quantity of oil in cooperation with compressor manufacturer
- Alternative implementation of cooling applications



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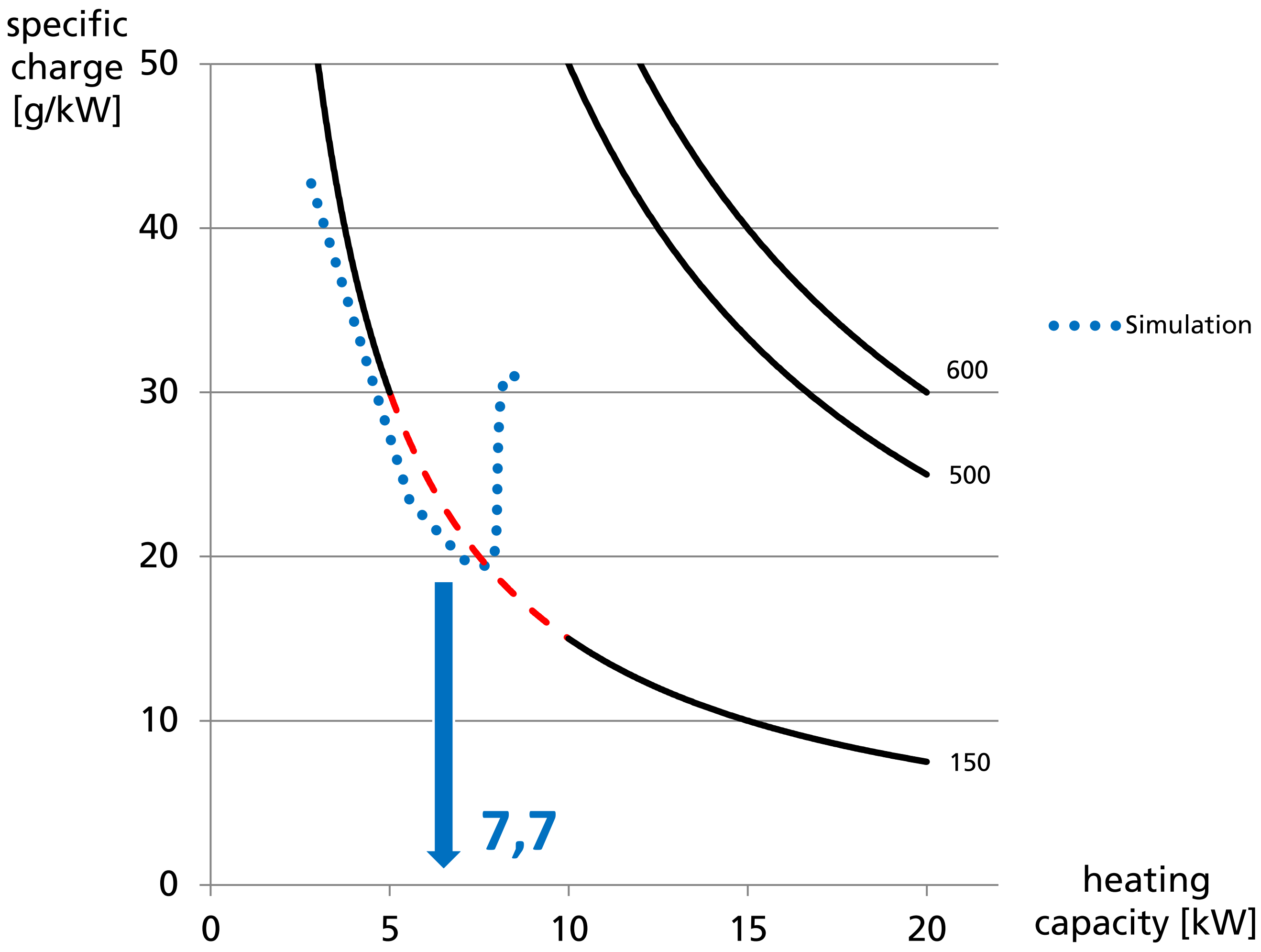
➢ **Simulation results for B0/W35 @120Hz, SH10K (IMST-Art):**

  ➢ design meets the addressed capacity range, predicted COP: 3.6 (60Hz)



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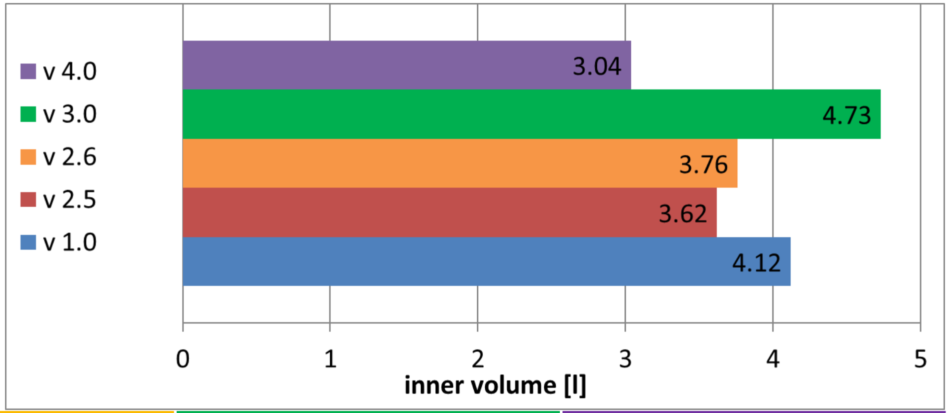
Measurements and results

Evaluation of four different configurations

- Two different compressor types
- Different heat exchanger types
- Variation of temperatures, superheat, compressor speed, refrigerant charge



	V 1.0	V 2.5	V 2.6	V 3.0	V 4.0
Compressor (all ~30cm³ displacement)	Scroll Manufacturer 1	Rotary v1 Manufacturer 2	Rotary v1 Manufacturer 2	Rotary v1 Manufacturer 2	Rotary v2 Manufacturer 2
Condenser	Long Asymmetric 16 Plates	Long Asymmetric 16 Plates	Short Asymmetric 38 Plates	Short Asymmetric 46 Plates	Short Asymmetric 38 Plates
Evaporator	Long Asymmetric 16 Plates	Long Asymmetric 16 Plates	Long Symmetric 16 Plates	Long Symmetric 28 Plates	Long Symmetric 16 Plates
Piping	Pipes v1	Pipes v1	Pipes v1	Pipes v2	Pipes v1

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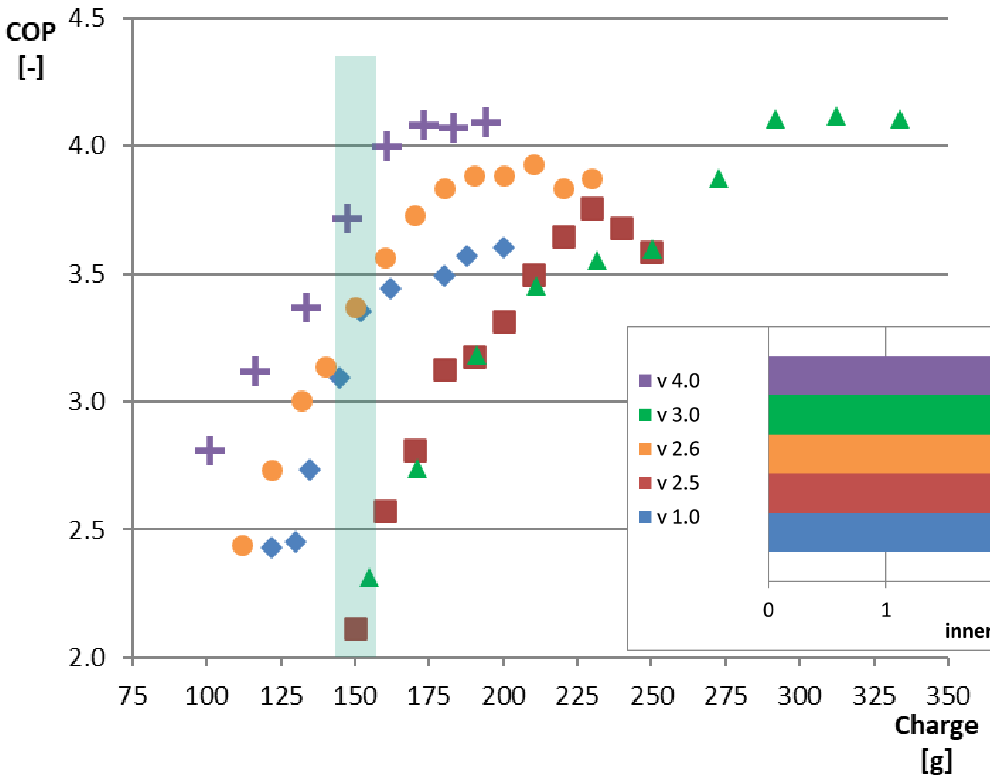
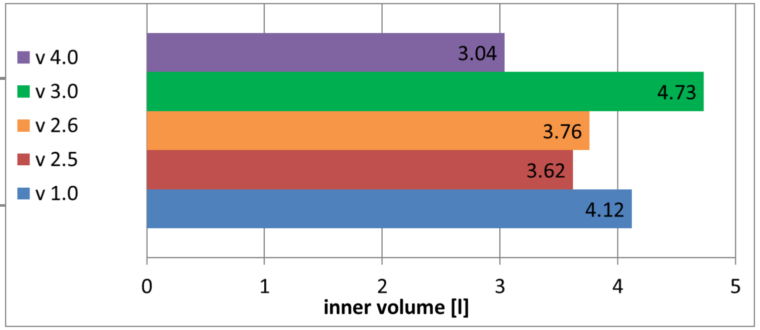
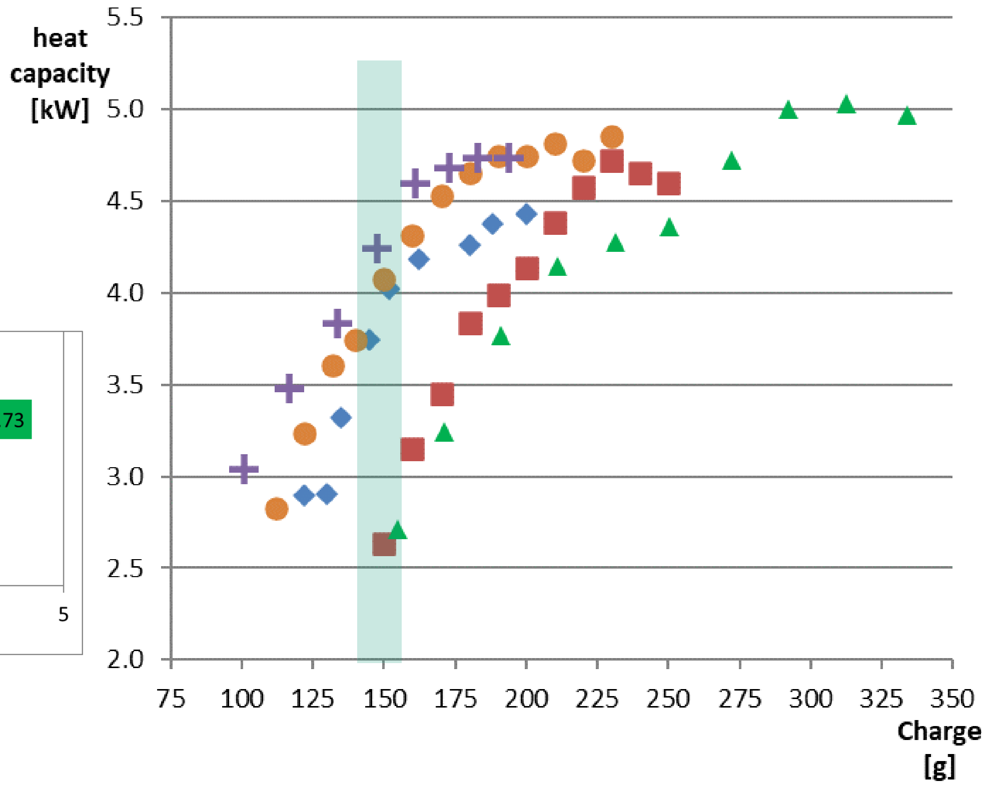
Measurements and results

Results for B0/W35, SH10K, @F50%







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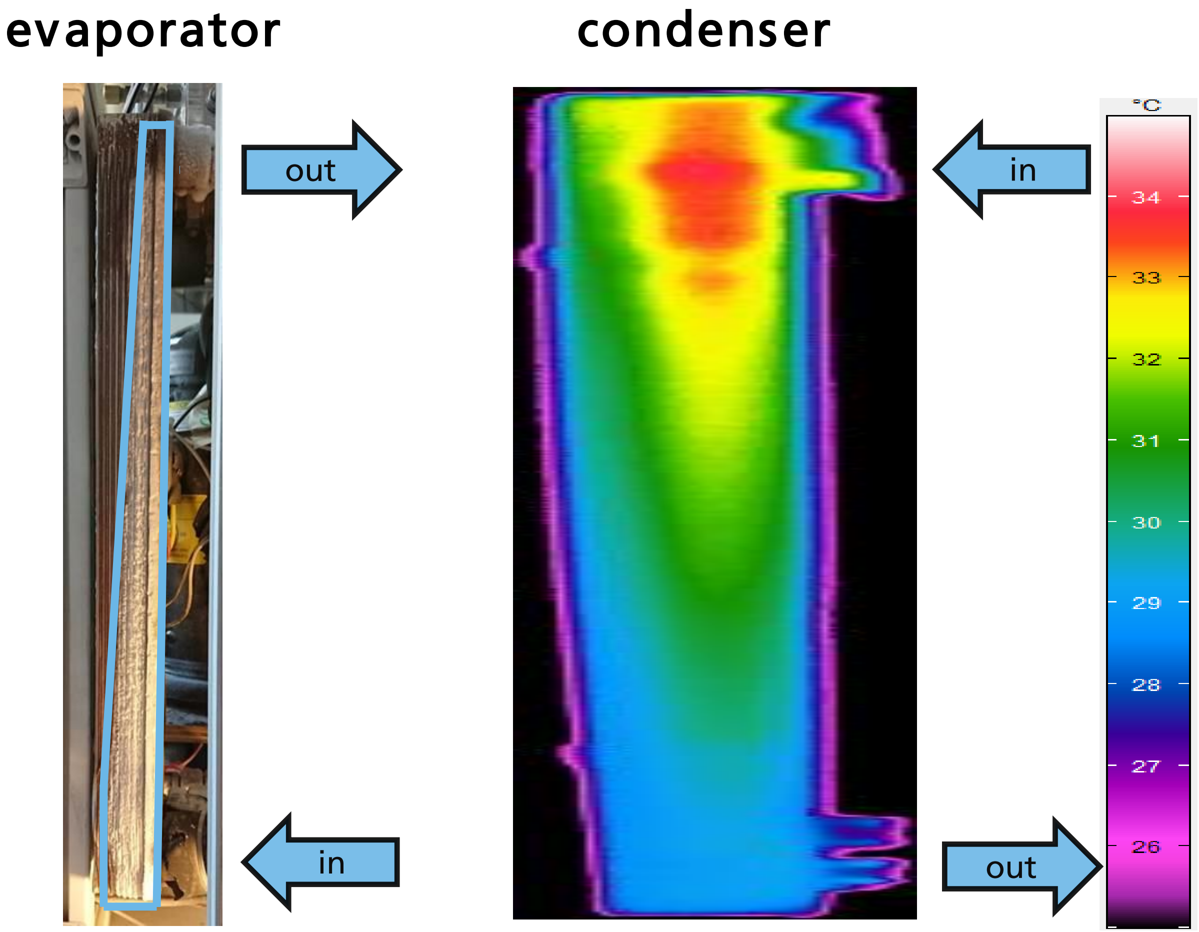
Measurements and results

- Visual analysis of the heat exchangers with pictures of the ice profile and thermography indicates maldistribution.
- Maldistribution leads to higher temperature differences/ reduced COPs.



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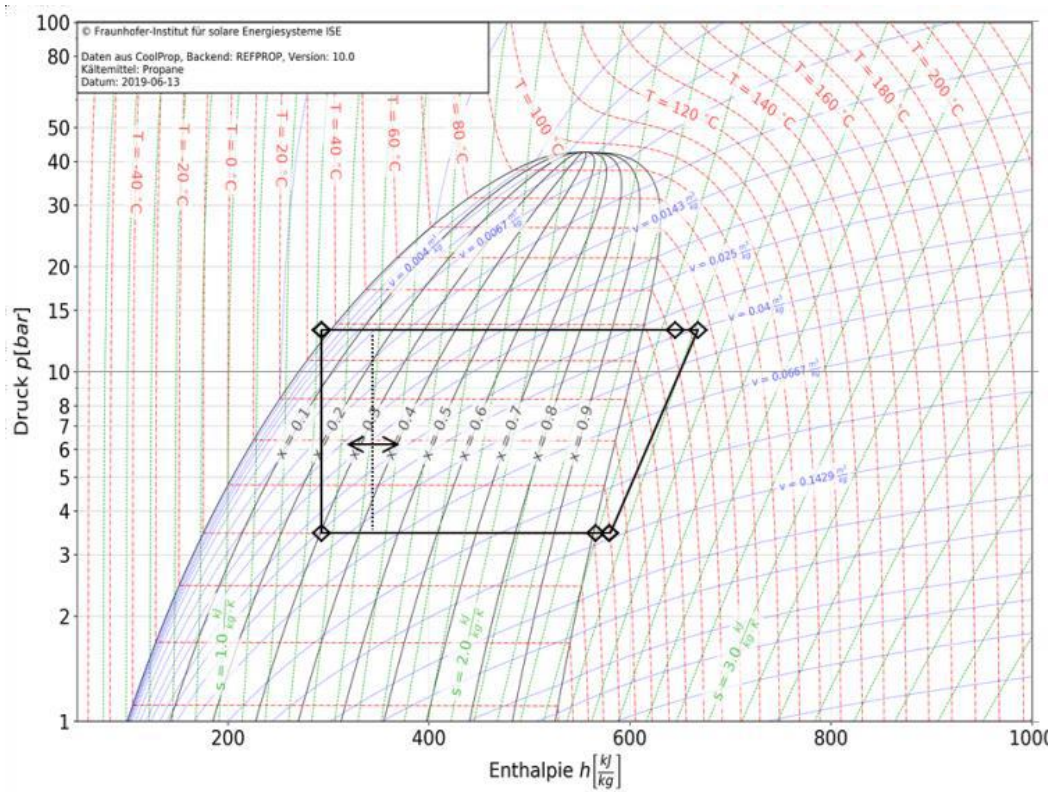
Operation of strongly charge reduced refrigerant circuits

- Refrigerant charge vs:
  - Performance
  - Stability
  - Reliability
- Brine to water only
- Alternative solutions needed
  - Exploitation of air as source
  - Cooling and defrost mode



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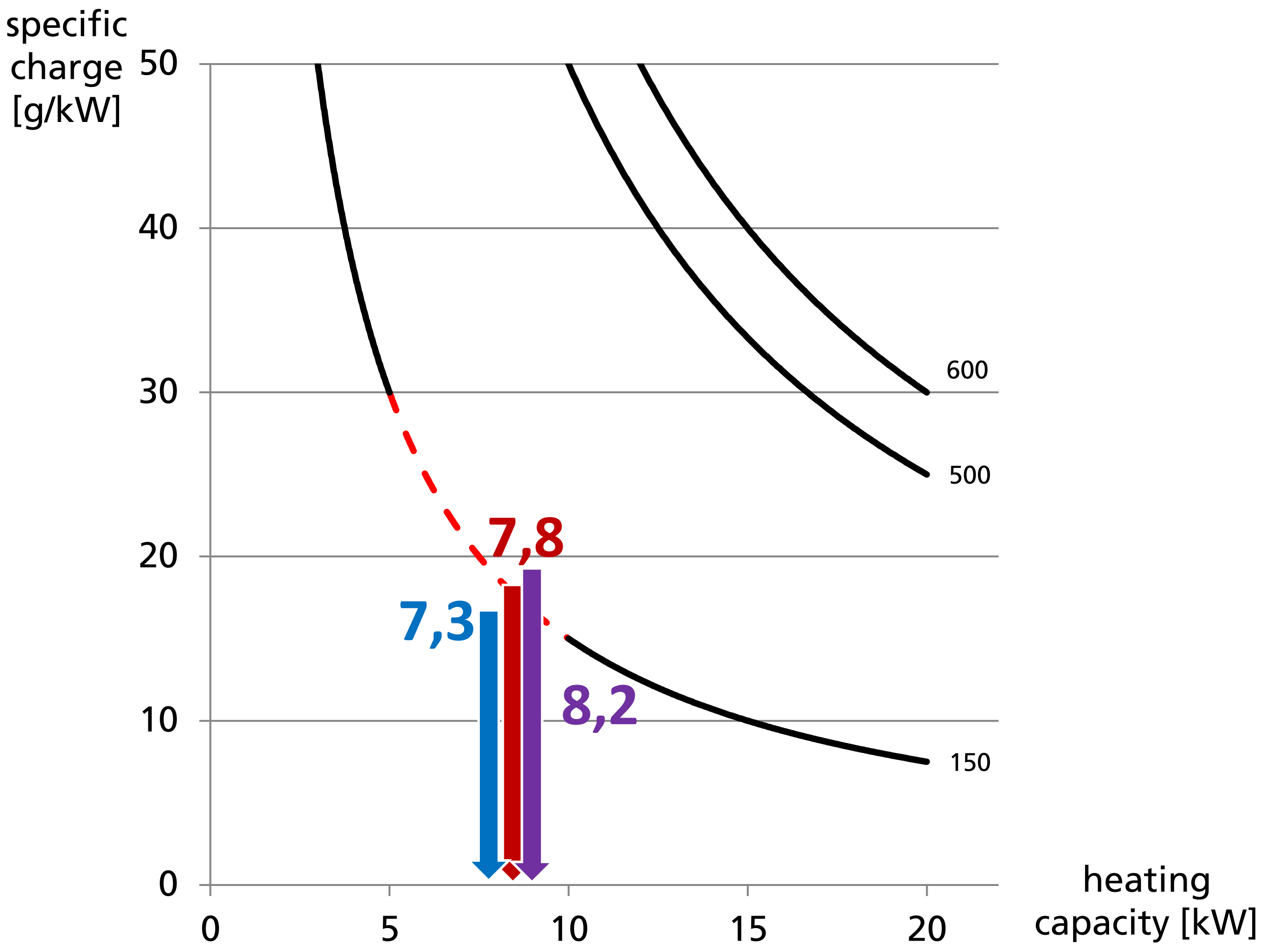
Summary

- Using 150 g propane a heating capacity of ~8 kW was achieved – corresponding to 75 % charge reduction.
- Combination of components (compressor speed, different HX designs) and operation (superheat, subcool) gives a wide range of enhancing COP **and** heating capacity.
  - well designed single components
  - more equalized flow distribution in heat exchangers
  - insulation of components



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Project consortium LC150

KERMI | BDR Thermea | VAILLANT GROUP | Bosch | Viessmann | ait DEUTSCHLAND CREATE A BETTER CLIMATE | REGLI ENERGY SYSTEMS | . . .

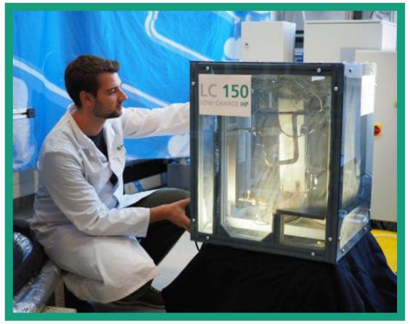
Steering Committee, definition of requirements, receipt of results and access to IPs

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

Federal Ministry for Economic Affairs and Energy

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

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag



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

4,8 Mio. € project budget, 2.5 years, 1.10.2020 – 31.03.2023

- Design rules and Operating strategies by
  - Component testing (heat exchangers, compressors, valves etc.) in single component and module tests and in broad cross evaluation
  - Validation of simulation tools
- Standardization/ simplification/ safety aspects
- Network and platform for manufacturers and component suppliers

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Upcoming tasks

Single component measurements

PHE + compressor

Cross evaluation of promising components in system test bench

Long term measurements for best of variants

+

Operation strategies for strongly charged reduced systems

+

Transformation of measurement data into simulation environment

Proposal of 2-3 charge reduced brine to water refrigerants circuits (4-12kW)

+

Generic risk analysis and identification of suitable supporting actions

2020	2021	2022	2023

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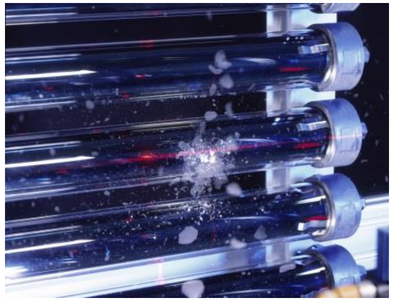
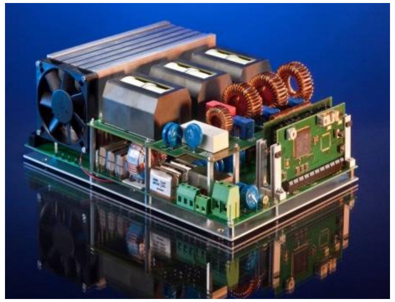
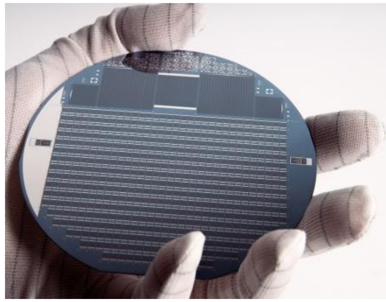
Thank you for your Attention!

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