Bachelor thesis presentation

Model-based investigation and experimental validation
of evaporator interconnections
for thermal performance enhancement
for use in refrigerated display cabinets

EMERSON

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Model-based investigation and experimental validation of evaporator interconnections for thermal performance enhancement for use in refrigerated display cabinets

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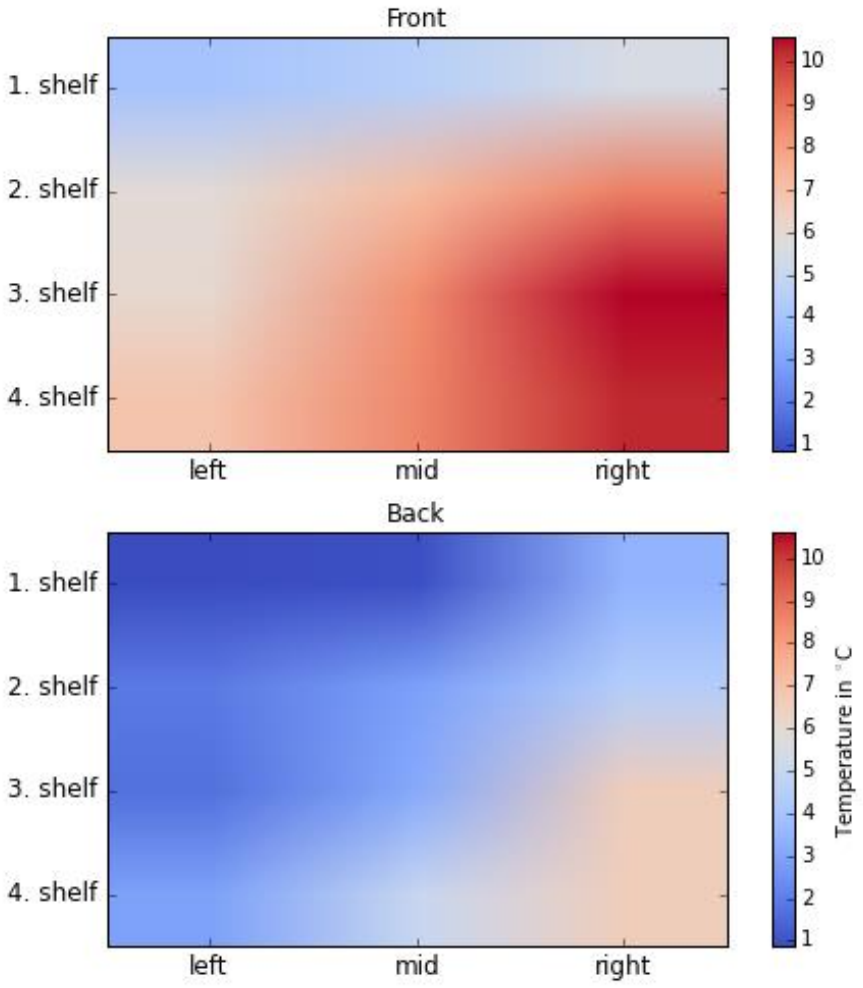
Integrated display cabinet

Problems:

- Product temperature between -1°C and 5°C can not be achieved
- Refrigerant capacity of 150g propane per circuit is too low
- Bad air distribution

Necessary Enhancements:

- Increase cooling capacity
- Reduce refrigerant capacity
- Improve air distribution



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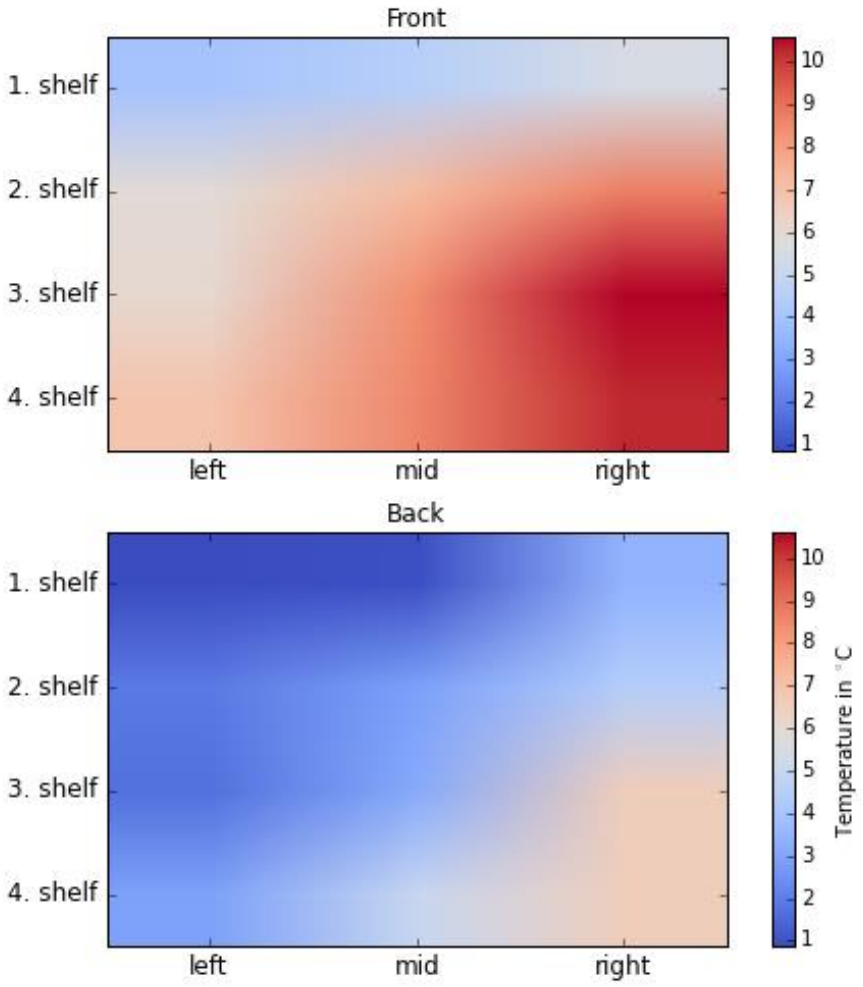

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Investigations on the IDC150

- Oil filling: 3MAF vs HATCOL 4467
  - Refrigerant solved in oil?
  - Bad oil return?
- Defrost intervals: 4h vs demand defrost
  - When is the best time to defrost?
- Compressors: ZB09KAU-TFD – Hybrid (aluminium) vs Standard (copper)
  - Which compressor provides better cooling capacity?
- Evaporator: AHT vs LIDL V1 vs LIDL V2
  - 2 rowed AHT-evap → 4 rowed LIDL-evap
  - Modification of the coil arrangement
  - Building and validation of a simulation model to evaluate the new coil arrangement

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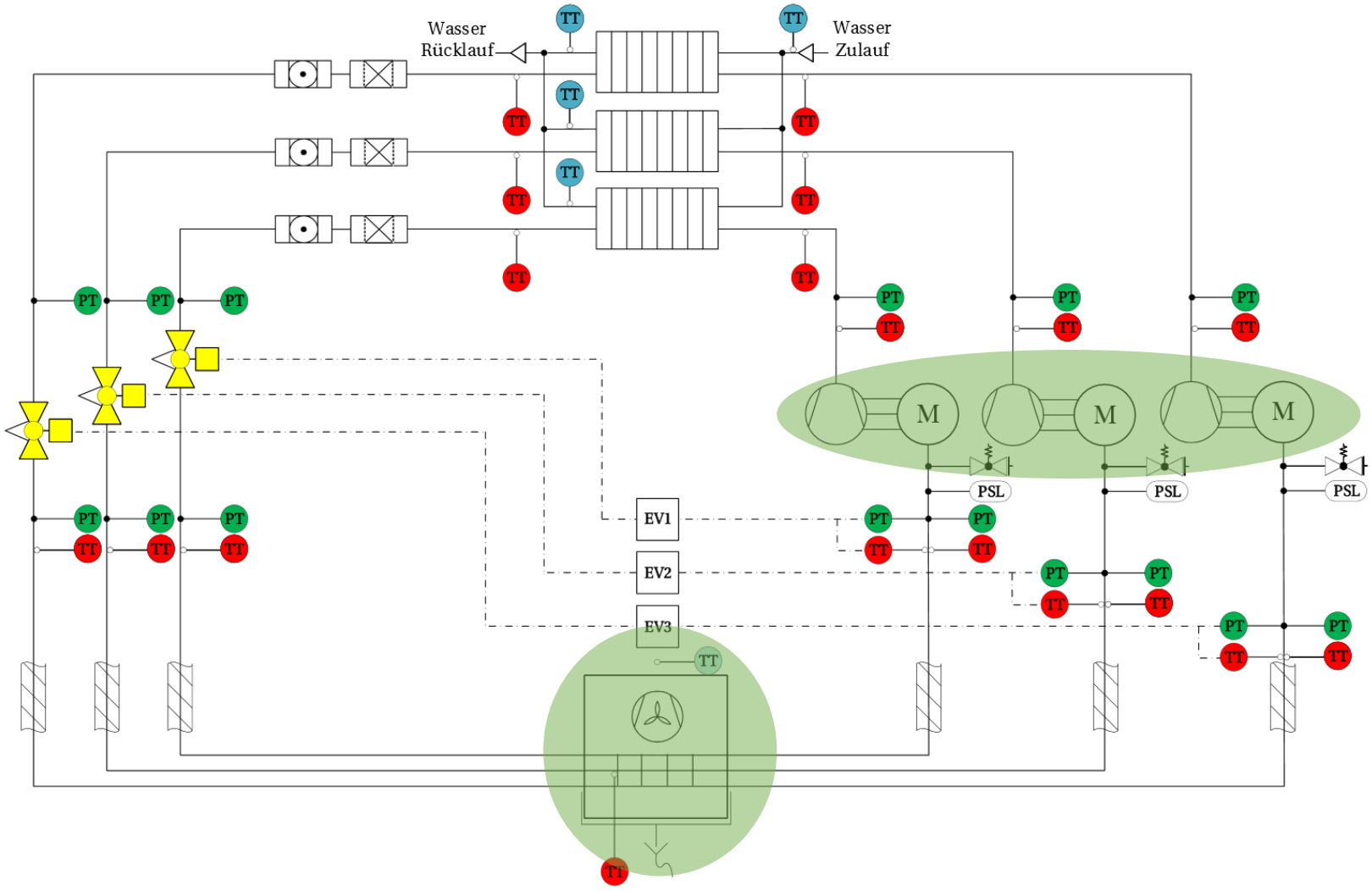
Cooling circuits



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Oil filling: 3MAF vs HATCOL 4467

Problems:

- Refrigerant solved in oil?

⇒ Calculation of the solubility of both oils

⇒ Loss of cooling capacity?

- Oil trapped in condenser and evaporator?

⇒ Using a flushing device to check for remaining oil

Oil filling: 3MAF vs HATCOL 4467

	Properties	10% Oil in Evaporator	80% Oil in Compressor	10% Oil in Condenser
HATCOL 4467	Viscosity (cSt)	3.72	38.66	0.89
	Density (g/cm³)	0.79	0.94	0.73
	Solubility (%)	35.4 %	5.0 %	37.1 %
	Refrigerant in oil (g)	13.09	17.55	12.79
	Refrigerant in oil (%)	8.7 %	11.7 %	8.5 %
3MAF	Viscosity (cSt)	1.95	17.73	0.87
	Density (g/cm³)	0.75	0.93	0.70
	Solubility (%)	41.0 %	5.2 %	41.6 %
	Refrigerant in oil (g)	14.53	18.07	13.80
	Refrigerant in oil (%)	9.7 %	12.0 %	9.2 %
	DF Qty of refrigerant 3MAF VS HATCOL 4467 (g)	**1.45**	**0.52**	**1.01**

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Oil filling: 3MAF vs HATCOL 4467

	3MAF	HATCOL 4467
el. Leistung Verdichter [W]	2436	**2542**
Leistung Verdampfer [W]	5383	**5442**
Leistung Kondensator [W]	7589	**7882**
EER	2.21	**2.14**

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Oil filling: 3MAF vs HATCOL 4467

Problems:

- Refrigerant solved in oil?

⇒ Calculation of the solubility of both oils

⇒ Loss of cooling capacity

- Oil trapped in condenser and evaporator?

⇒ Using a flushing device to check for remaining oil

Results:

⇒ The solubility of refrigerant in 3MAF is higher than in HATCOL 4467

⇒ More refrigerant is solved in 3MAF

⇒ No remaining oil in heat exchangers!

⇒ HATCOL 4467 provides better cooling capacity for the cost of a worse efficiency

Investigations on the IDC150

- Oil filling: 3MAF vs HATCOL 4467 → **HATCOL 4467**
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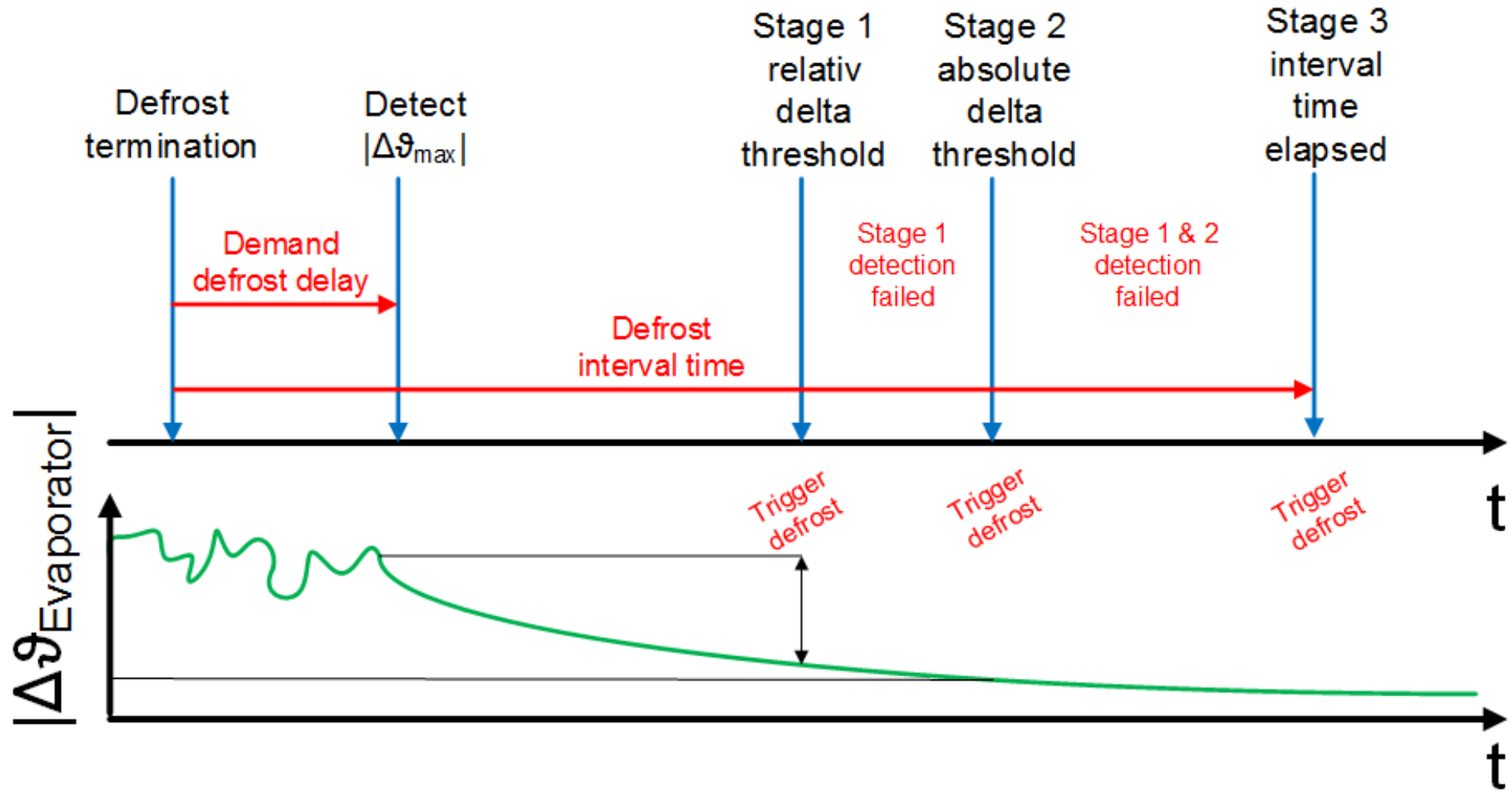
Defrost intervals: 4h vs demand defrost

Problems:

- Demand defrost interval is exactly 3h

  ⇒No Detection of Ice?
- Need to identify the perfect defrost interval

Defrost intervals: 4h vs demand defrost



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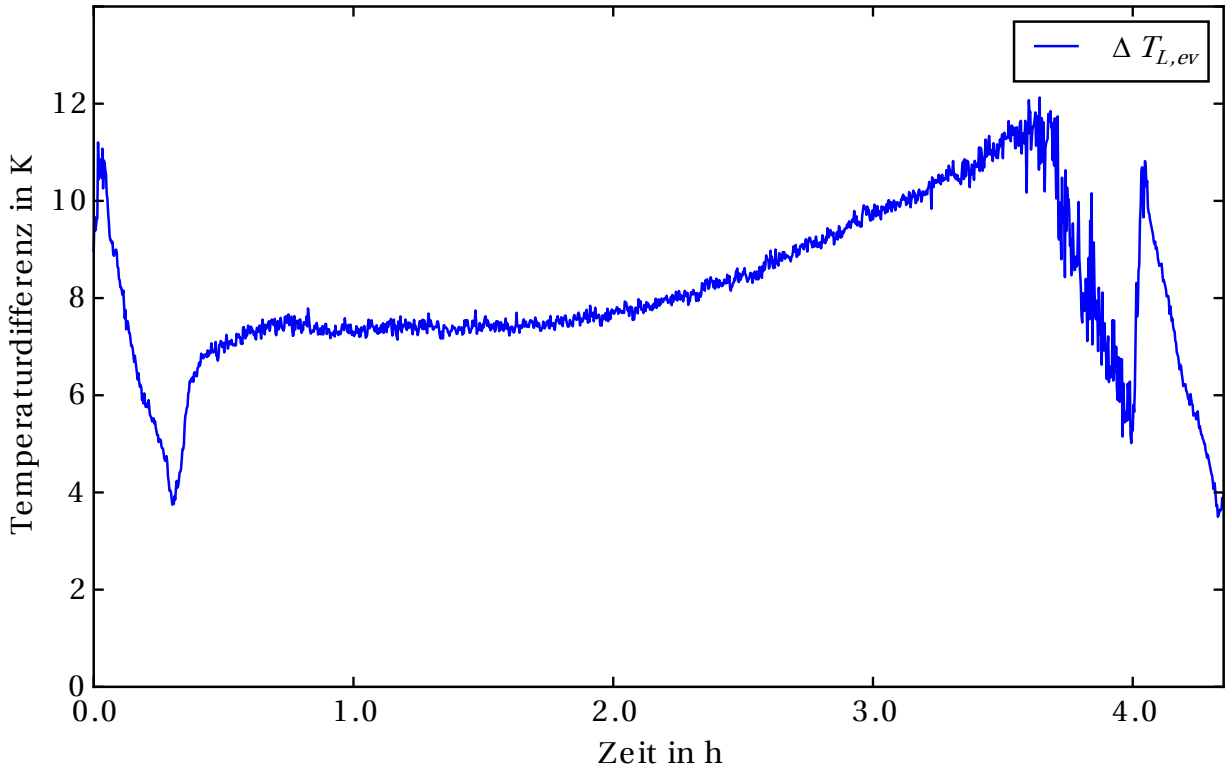

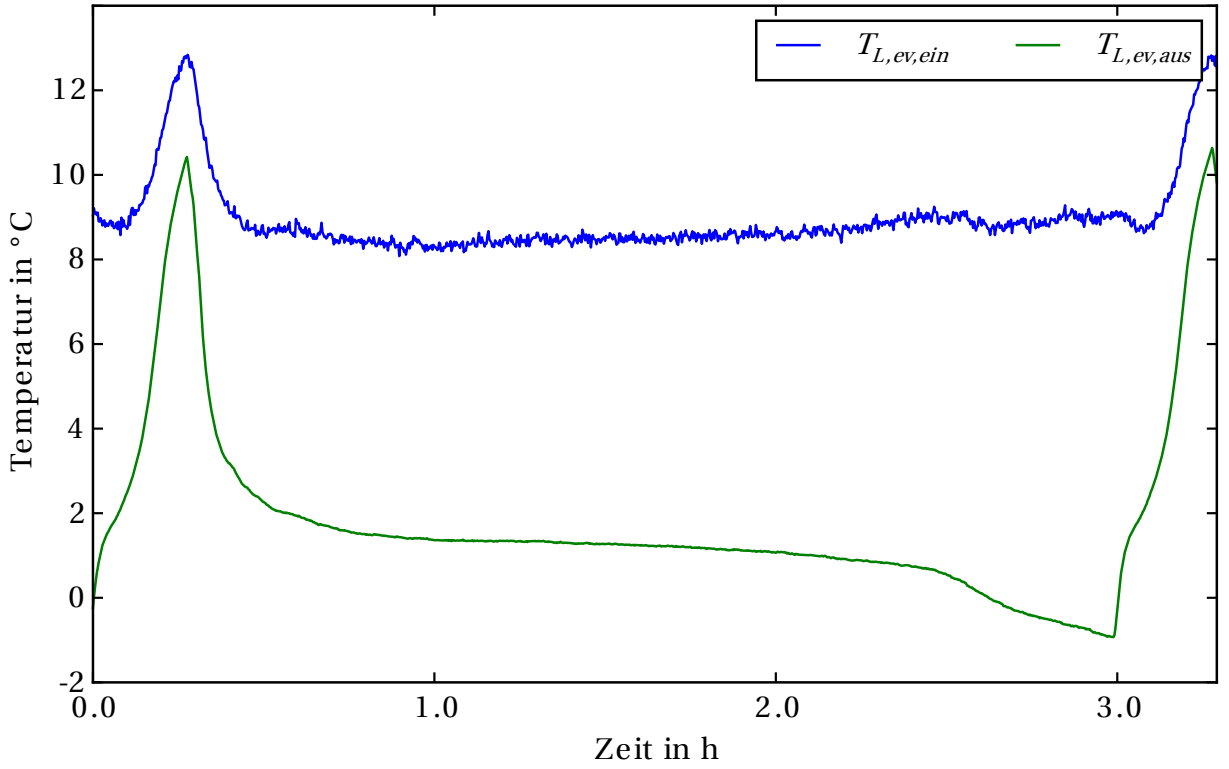

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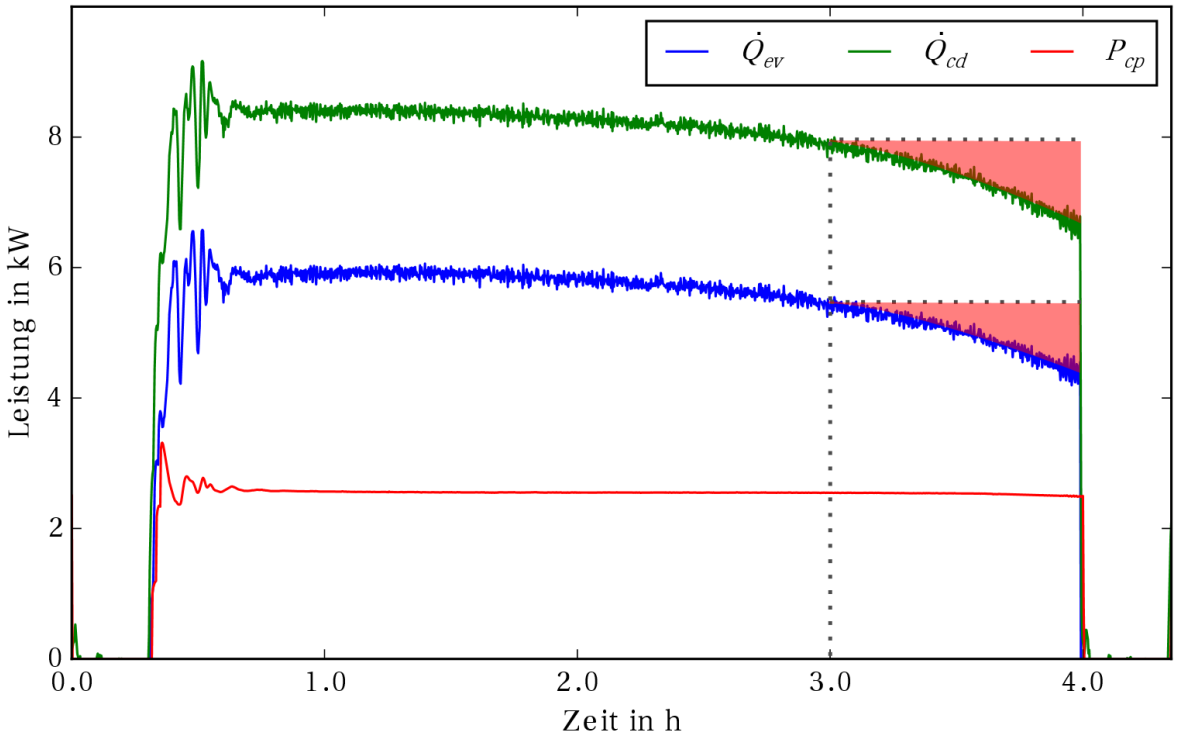

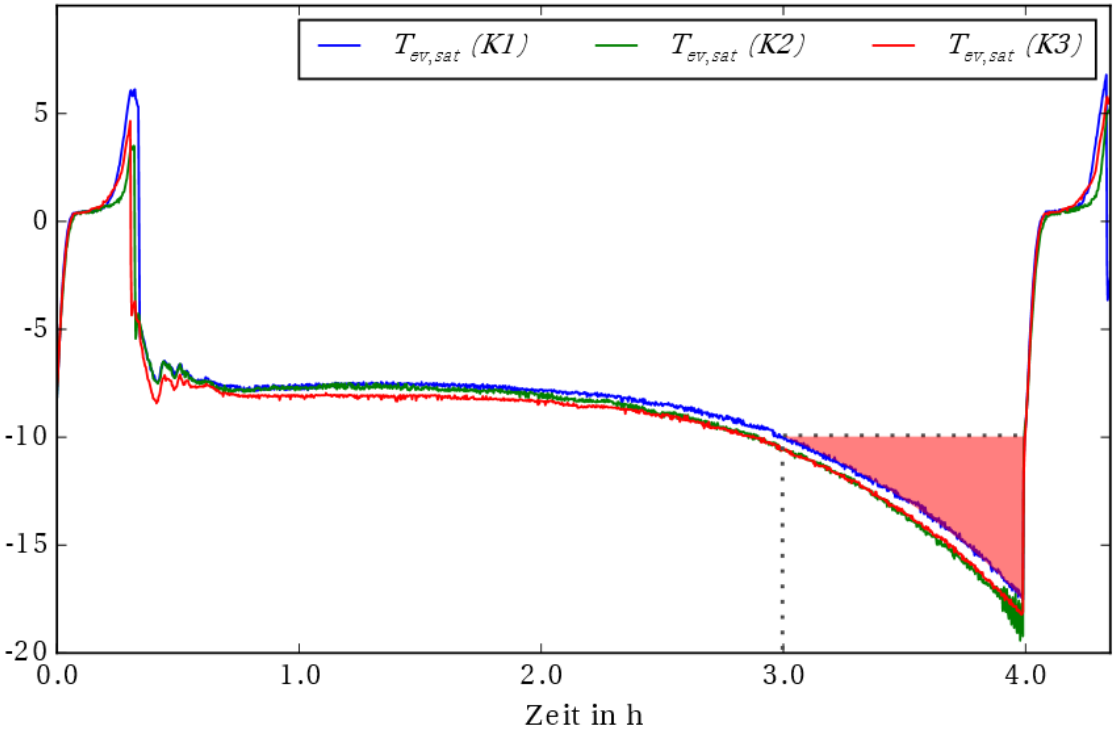

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Defrost intervals: 4h vs demand defrost

	4h	Demand (3h)
el. Leistung Verdichter [W]	2542	2554
Leistung Verdampfer [W]	5442	**5770**
Leistung Kondensator [W]	7882	**8230**
EER	2.14	**2.26**

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Defrost intervals: 4h vs demand defrost

Problems:

- Demand defrost interval is exactly 3h
  - ⇒No Detection of Ice?
- Need to identify the perfect defrost interval

Results:

⇒ ΔT rises → Defrost is not triggered

- ⇒ Convection heat transfer ↗ → Induction rate of the chamber air ↗

⇒ 3h defrost interval

- ⇒ higher cooling capacity
- ⇒ higher efficiency

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Compressors: Hybrid vs Standard

Problems:

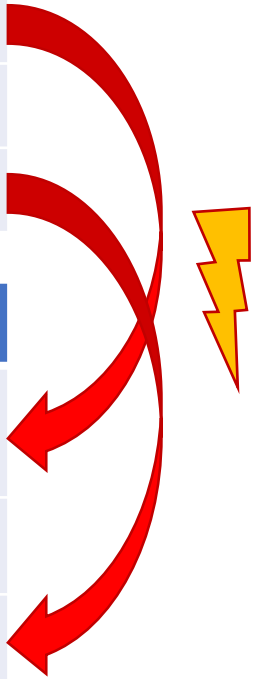
- Which compressor provides better cooling capacity?
  - ZB09KAU-TFD Hybrid = Aluminium motor
  - ZB09KAU-TFD Standard = Copper motor

Compressors: Hybrid vs Standard

Select data	Hybrid	Standard
el. Leistung [W]	2490	2400
Kälteleistung [W]	6840	6870
Mass flow [g/s]	7.96	8.00

⇒Select data only valid for 0K subcooling / 0% quality (meas.: 6%-23% quality)

Meas. data	Hybrid	Standard
el. Leistung Verdichter [W]	2554	**2697**
Leistung Verdampfer [W]	5770	**6161**
Mass flow (C2) [g/s]	8.79	8.29
Leistung Kondensator [W]	8230	**8652**
EER	2.26	**2.28**



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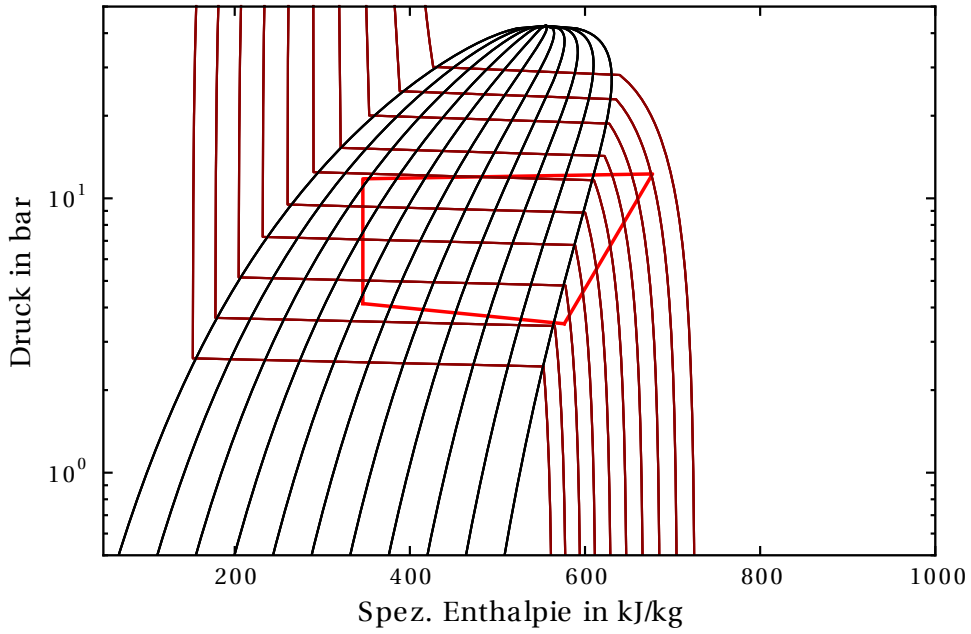
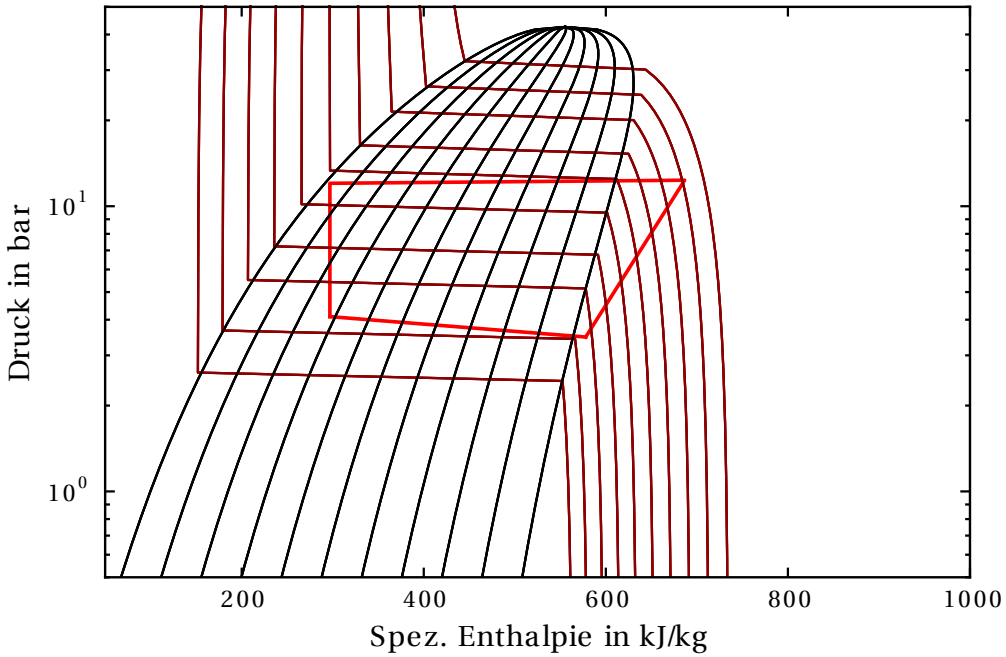
Compressors: Hybrid vs Standard





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Compressors: Hybrid vs Standard

Problems:

- Which compressor provides better cooling capacity?
  - ZB09KAU-TFD Hybrid = Aluminium motor
  - ZB09KAU-TFD Standard = Copper motor

Results:

⇒ Standard model provides **400 W** more cooling capacity than hybrid model

⇒ Select data only valid for 0K subcooling / 0% quality
(meas.: 6%-23% quality)

⇒ Power curve of the aluminium motor is different than the one of the copper motor

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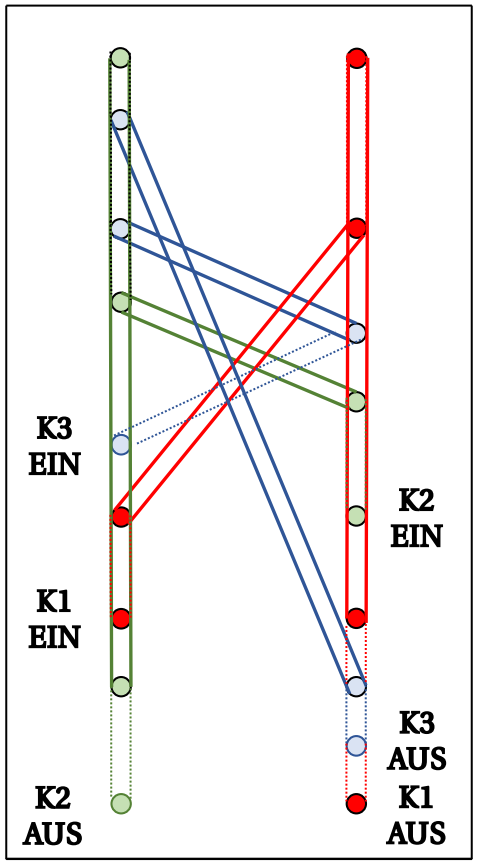
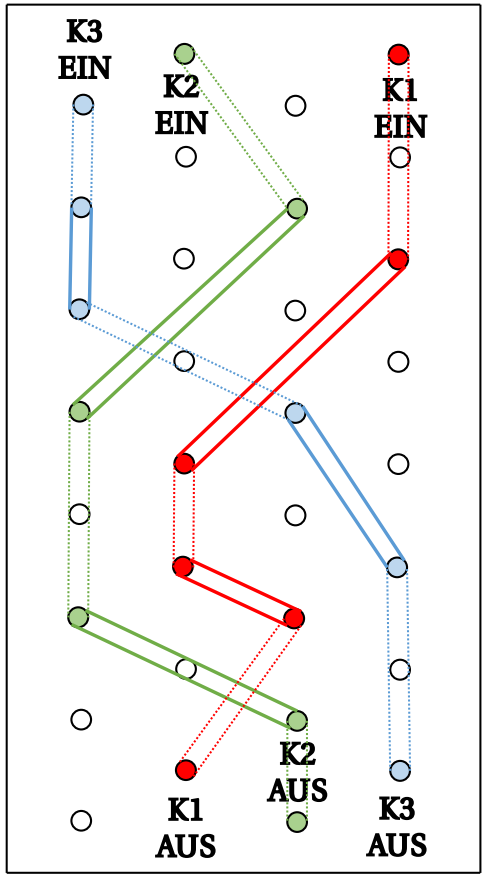
Evaporator: AHT vs LIDL V1 vs LIDL V2

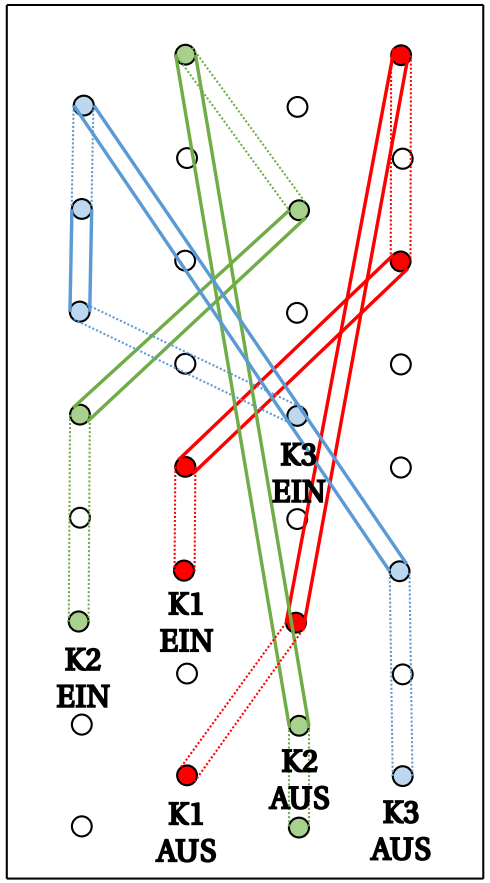
Problems:

- Does the 4-rowed LIDL-evap provide a better heat transmission than the 2-rowed AHT-evap?
- Does a change in the coil arrangement increase the the cooling capacity?

Evaporator: AHT vs LIDL V1 vs LIDL V2







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Evaporator: AHT vs LIDL V1 vs LIDL V2

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