



Technische Hochschule
Ingolstadt



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Institut für
neue Energie-Systeme

CARNOT User Meeting
(Annual simulation of a hybrid)
Heat pump including
inverter control

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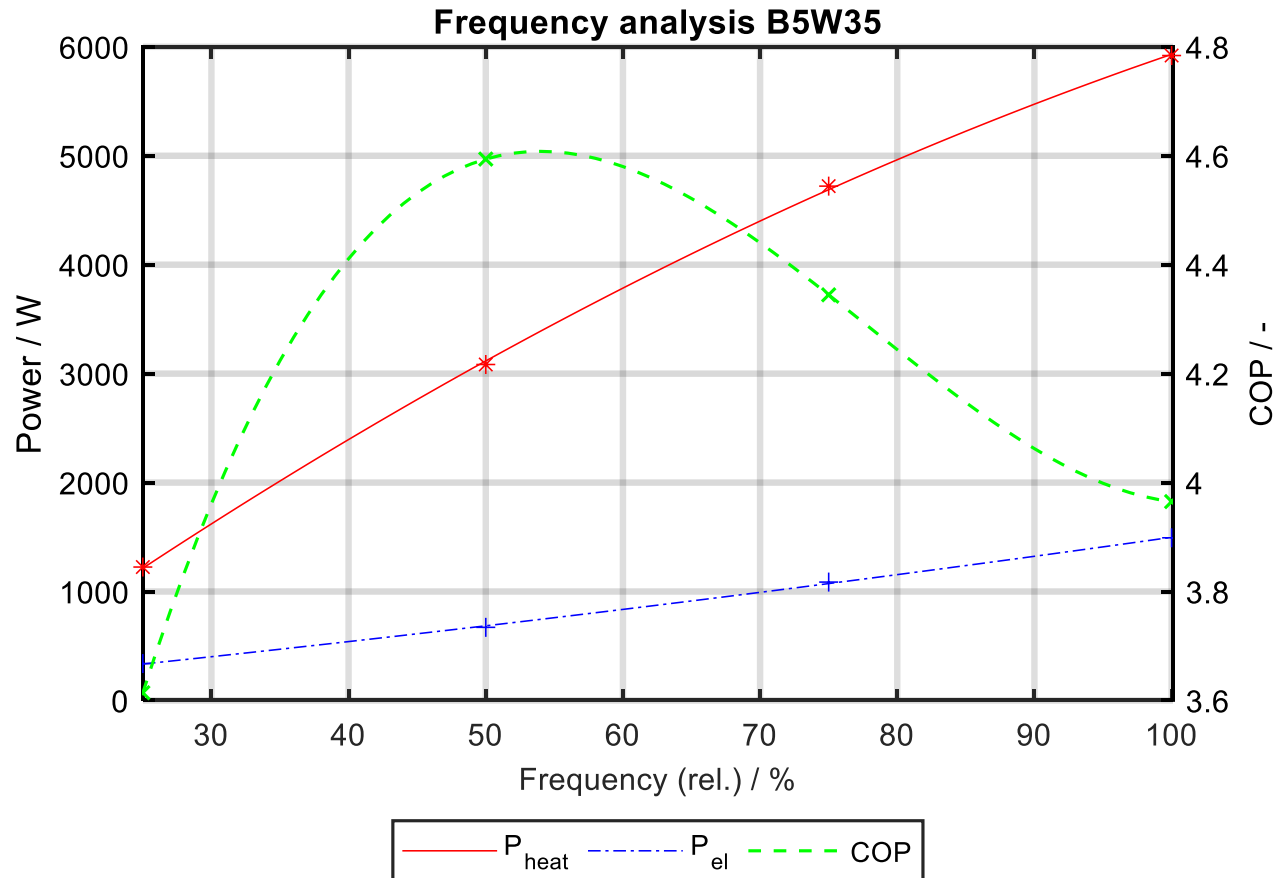
01.07.2022

1. Background
2. Additional steps
3. Discussion

- Modern heat pumps employ inverters to vary the heating power:
 - Usually between 25 to 100 %
 - Requires inverter (losses)
 - Reduces compressor starts significantly
- Effects on heat pump efficiency positive, but highly dependent on individual heat pump system

1 Background

Measurement

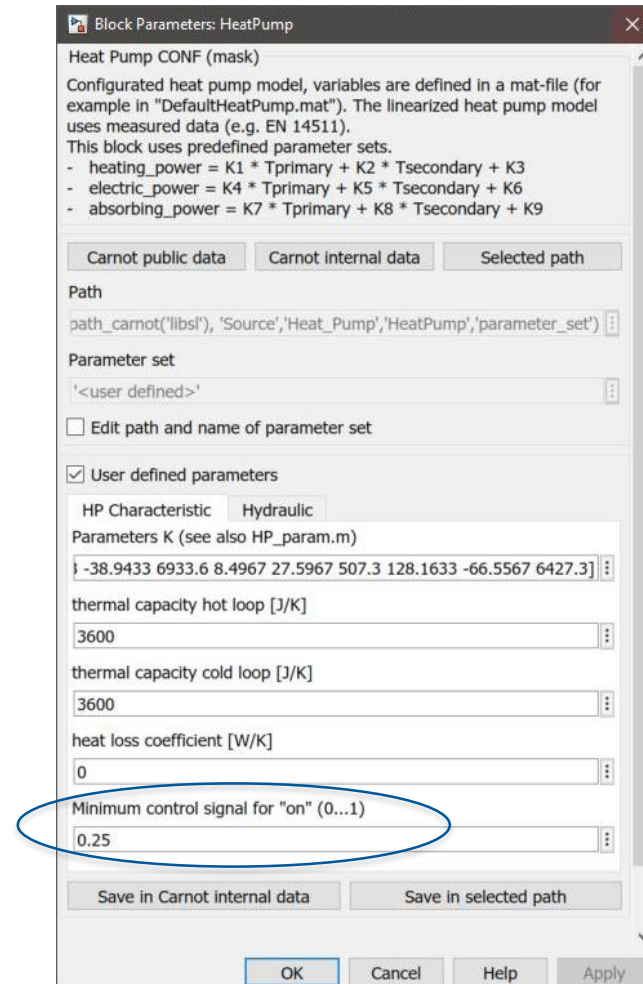


$$P_{\text{heat}} = -0.2641 * f^2 + 95.91 * f - 1018.8$$

1 Background

Implementation in CARNOT heat pump

- Current implementation in CARNOT model: „minimum control signal“
 - However: only factor on heating power \dot{Q}_{hot} and electrical power P_{elec}
- Couple of comparison simulations at B5W35, switching from 100 % to 50 %



Block Parameters: HeatPump

Heat Pump CONF (mask)

Configured heat pump model, variables are defined in a mat-file (for example in "DefaultHeatPump.mat"). The linearized heat pump model uses measured data (e.g. EN 14511). This block uses predefined parameter sets.

- heating_power = $K1 \cdot T_{\text{primary}} + K2 \cdot T_{\text{secondary}} + K3$
- electric_power = $K4 \cdot T_{\text{primary}} + K5 \cdot T_{\text{secondary}} + K6$
- absorbing_power = $K7 \cdot T_{\text{primary}} + K8 \cdot T_{\text{secondary}} + K9$

Carnot public data Carnot internal data Selected path

Path

path_carnot('libs'), 'Source', 'Heat_Pump', 'HeatPump', 'parameter_set'

Parameter set

'<user defined>'

☐ Edit path and name of parameter set

☒ User defined parameters

HP Characteristic Hydraulic

Parameters K (see also HP_param.m)

{ -38.9433 6933.6 8.4967 27.5967 507.3 128.1633 -66.5567 6427.3 }

thermal capacity hot loop [J/K]

3600

thermal capacity cold loop [J/K]

3600

heat loss coefficient [W/K]

0

Minimum control signal for "on" (0...1)

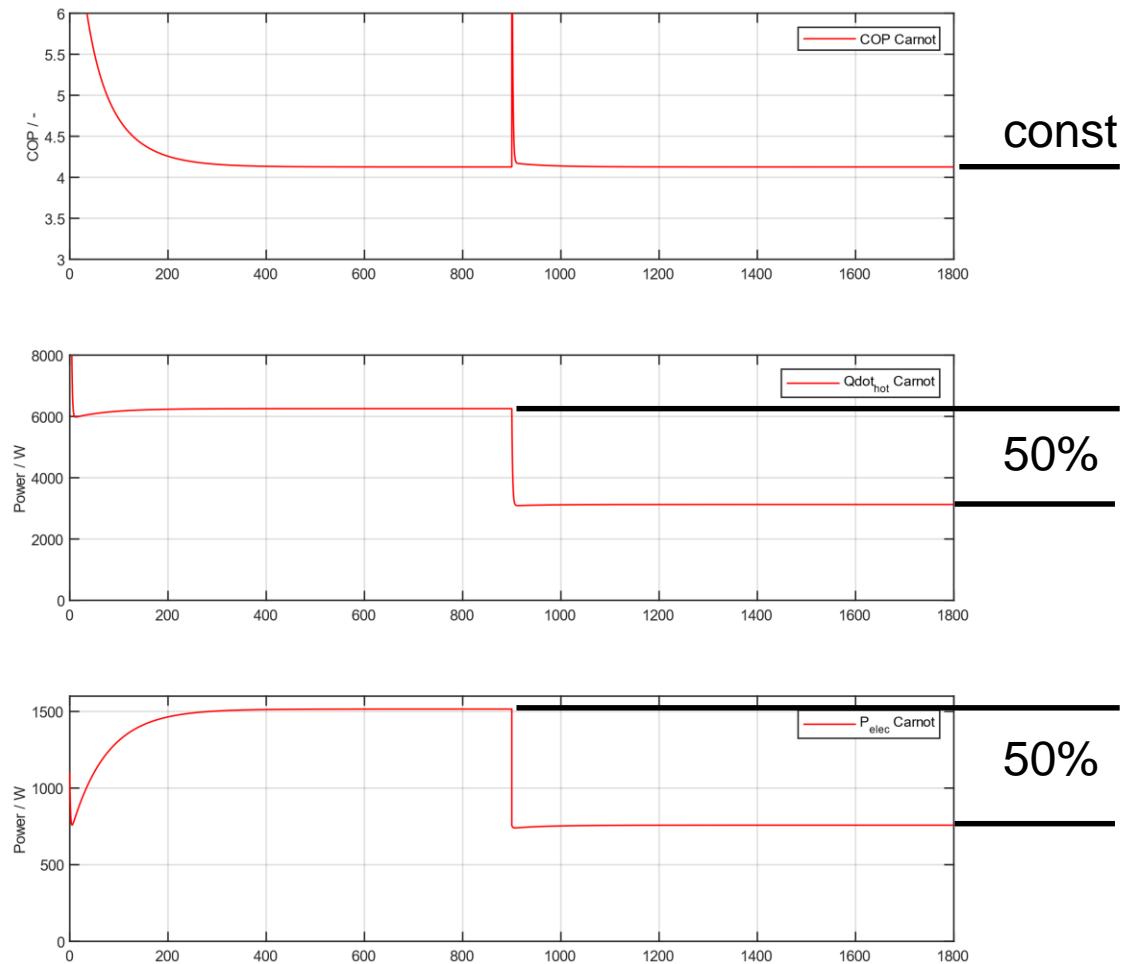
0.25

Save in Carnot internal data Save in selected path

OK Cancel Help Apply

1 Background

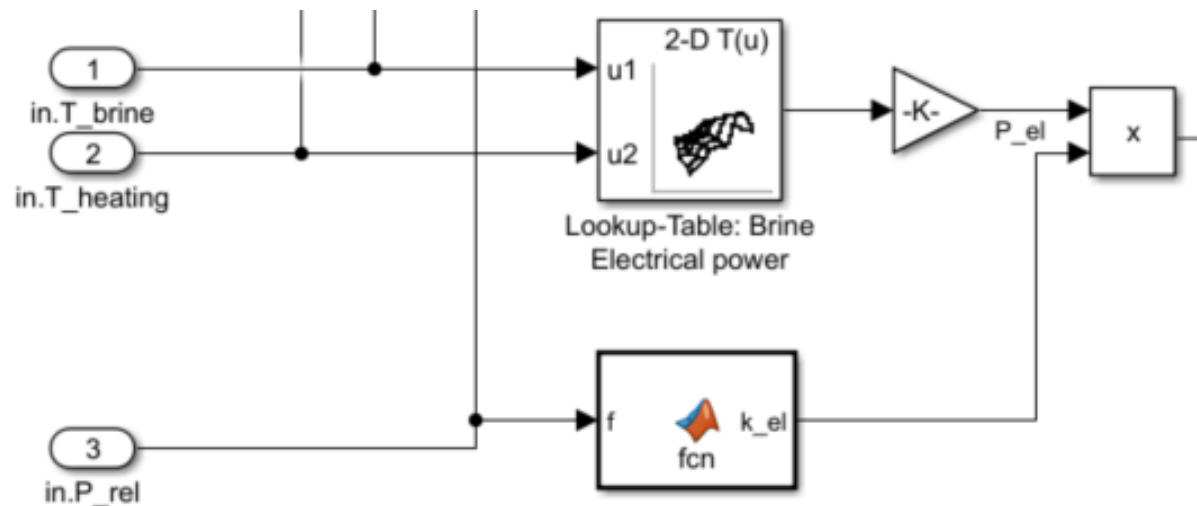
Implementation in CARNOT heat pump



2 Additional steps

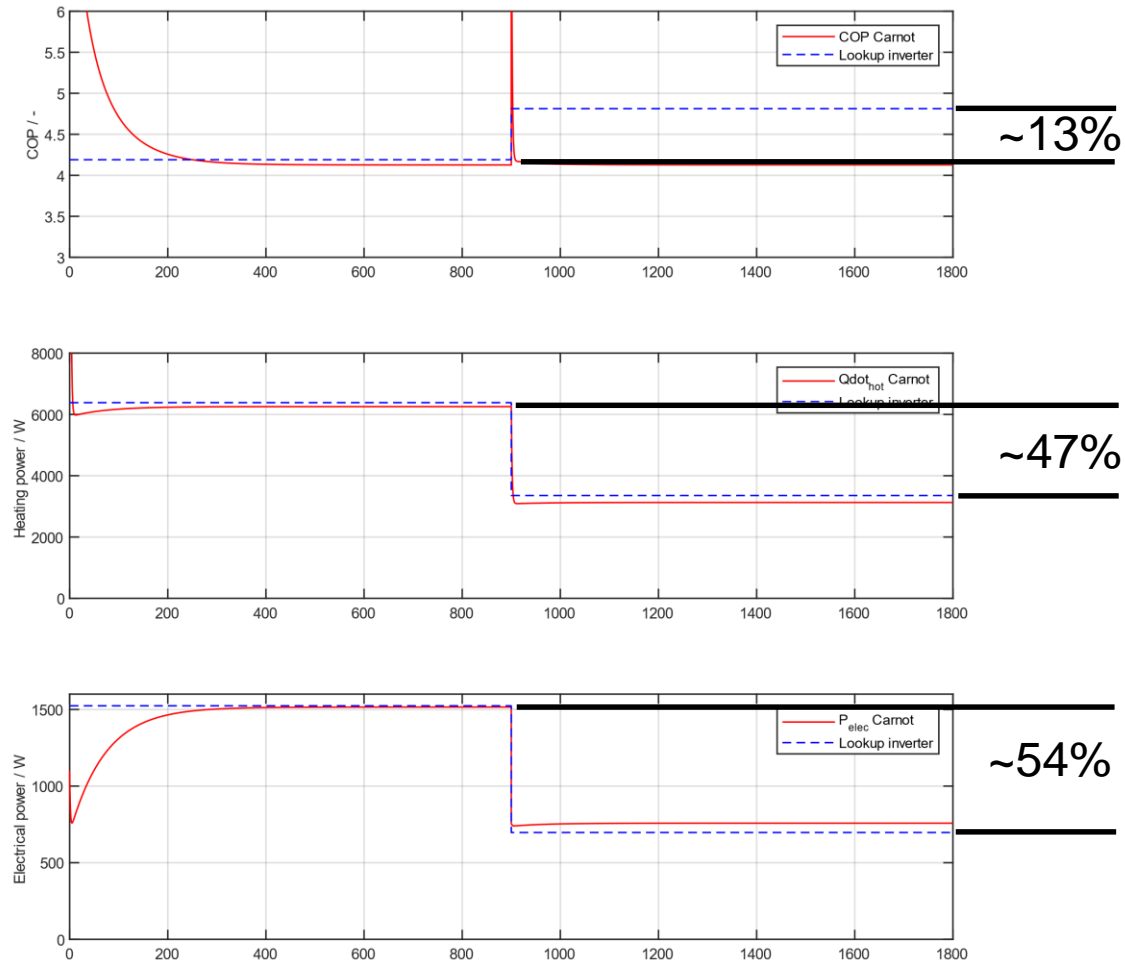
Lookup table with equation-based fit

- Switched to a lookup table with a correction factor
- Correction factor based on measurement (at one specific boundary condition point)



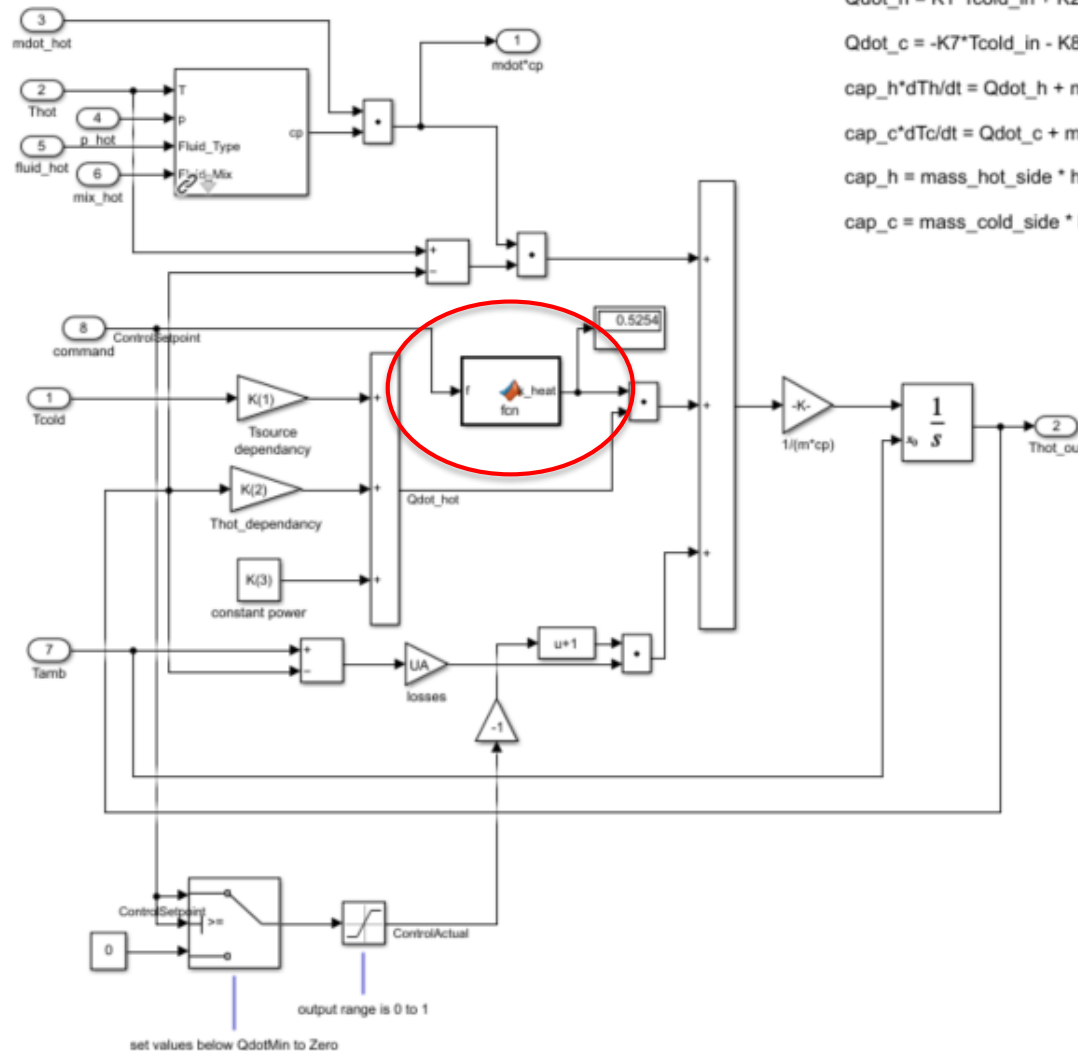
2 Additional steps

Lookup table with equation-based fit



2 Additional steps

Equation-based fit into CARNOT heat pump



$$\dot{Q}_{dot_h} = K1 \cdot T_{cold_in} + K2 \cdot T_{hot_out} + K3$$

$$\dot{Q}_{dot_c} = -K7 \cdot T_{cold_in} - K8 \cdot T_{hot_out} - K9$$

$$cap_h \cdot dTh/dt = \dot{Q}_{dot_h} + m_{dot_h} \cdot cp_h \cdot (Th_in - Th) + UA \cdot (Tamb - Th)$$

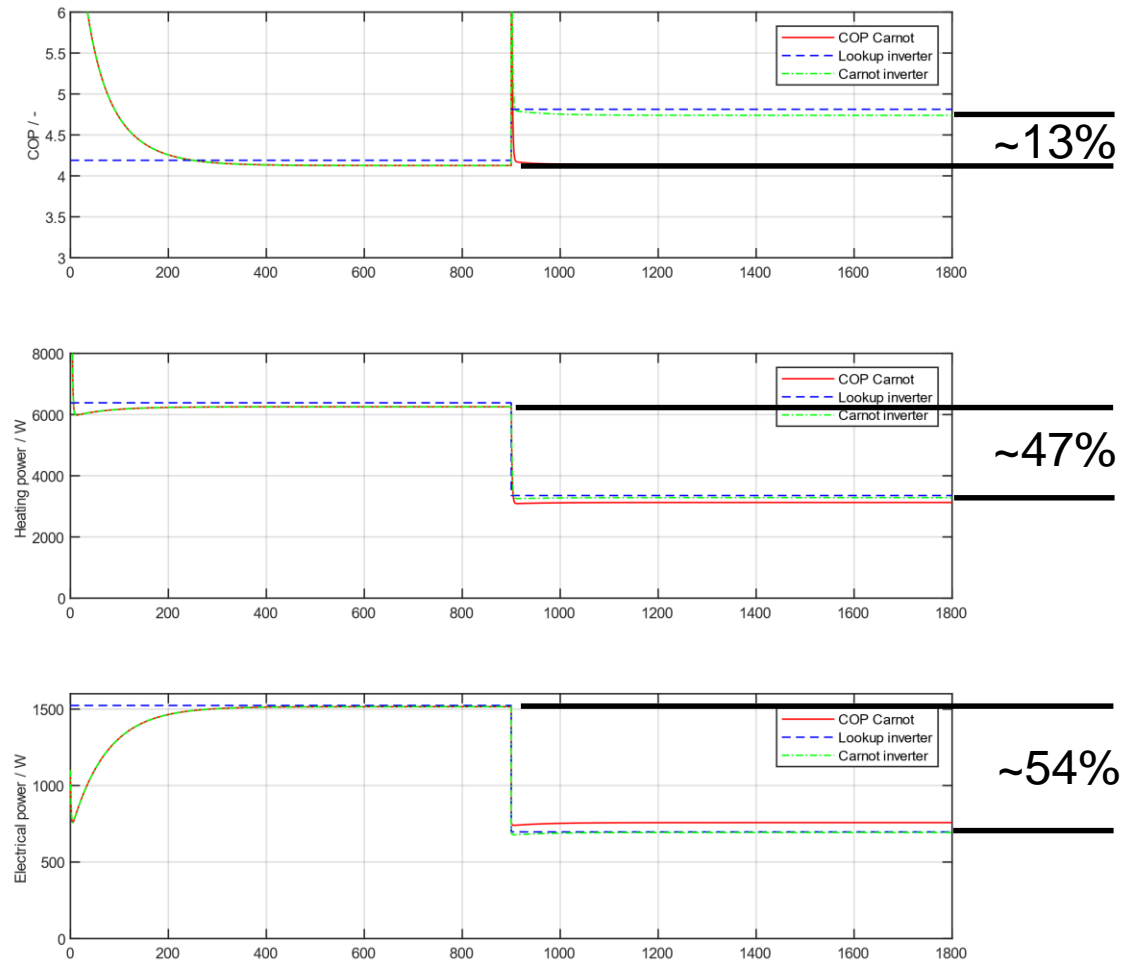
$$cap_c \cdot dTc/dt = \dot{Q}_{dot_c} + m_{dot_c} \cdot cp_c \cdot (Tc_in - Tc) + UA \cdot (Tamb - Tc)$$

$$cap_h = mass_hot_side \cdot heat_capactiy_hot_side$$

$$cap_c = mass_cold_side \cdot heat_capactiy_cold_side$$

2 Additional steps

Equation-based fit into CARNOT heat pump



3 Discussion

Issues with this implementation

- Implementation could be done in the same way like the heat pump model (parameter-based equation fit in external function)
- But: The precision with „fewer“ measurements is lacking.
 - Barely available from manufacturers
 - Own Measurements mean a lot of work (potentially)
 - Still, even with a single measurement or even a standard parameter set, the model should become more realistic in part-load situations

Thank you for the attention!

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