Technische Hochschule Ingolstadt
Institut für neue Energie-Systeme

Parallel operation of two heat sources in a DSHP

CARNOT User Meeting 2023

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26.06.2023

Agenda

1. **Introduction**
2. **Modelling approach**
3. **First results**

1. Introduction

Dual-Source Heat Pumps: Concepts

- **To benefit from advantages and limit disadvantages: Heat Pumps using multiple heat sources, e.g.:**
  - Air + solar
  - Ground + solar
  - Air + ground
  - More exotic applications like water + ground, waste heat + air etc.
- **Reduce size from ground source while achieving high efficiencies and limit noise**
- **Different hydraulic approaches: Several heat pump systems, brine cycles for heat sources, etc.**

1. Introduction

Dual-Source Heat Pumps: Aims

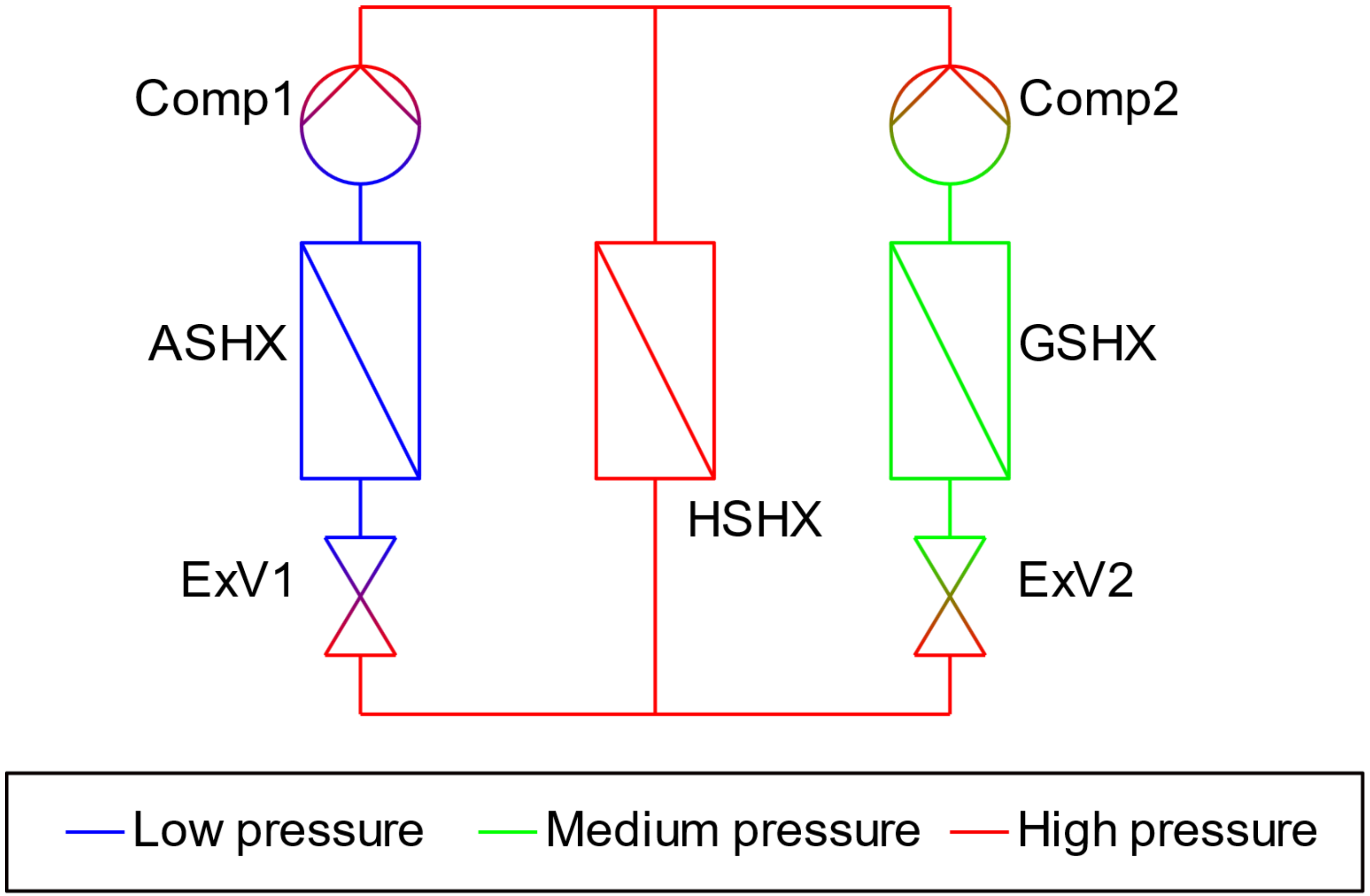
- **Reduce size: reduced annual load on ground source by using air source in spring, autumn, summer**
  - Reduces energy extracted from the soil (BHEs, horizontal, etc.)
- **Maintain high efficiency: switch to beneficial heat source according to ambient temperatures**
  - e.g. air source during high ambient temperatures, ground source during cold winter days
- **Reduce noise: switching to ground source during sensible times (e.g. night operation)**
  - reduces ventilator noise but not necessarily compressor noise (depends on the system)

→ Can in parts contradict themselves: optimization according to purpose necessary

1. Introduction

Novel hybrid heat pump system

- **Is it possible to operate both heat sources in parallel?**
  - Can reduce power load on each heat source
  - Non-trivial for the refrigerant cycle: for full flexibility and efficiency, separate evaporation pressures are needed



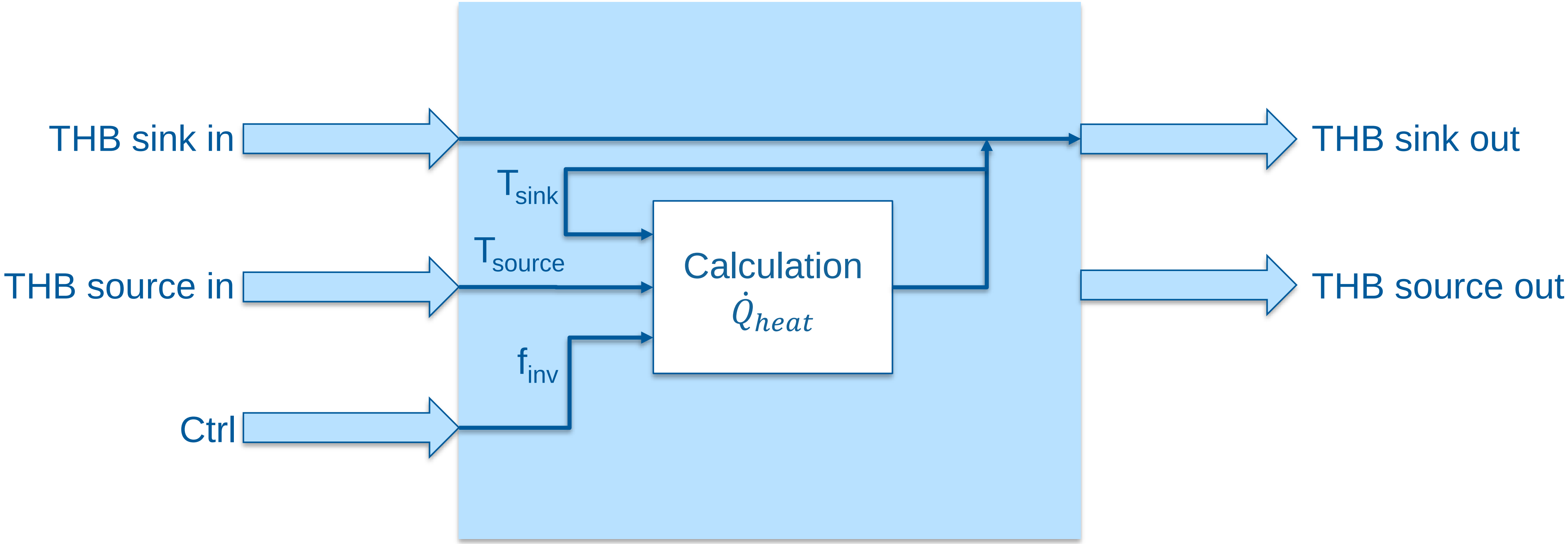
2. Modelling approach

- **Black box model first: based on experimental data and fast**
  - Refrigerant cycle simulation might follow later for verification and inter- as well as extrapolation
- **Many degrees of freedom: 3 temperatures (ambient air, brine, heating system/DHW) + 2 frequencies → 3^5 = up to 243 measurements for quadratic interpolation**
- **Solution: Comparison of parallel operation with overlying single source operation at certain boundary conditions**
  - Correction factors required

$$ASO * f_{air} + GSO * f_{ground} = PO$$

2. Modelling approach

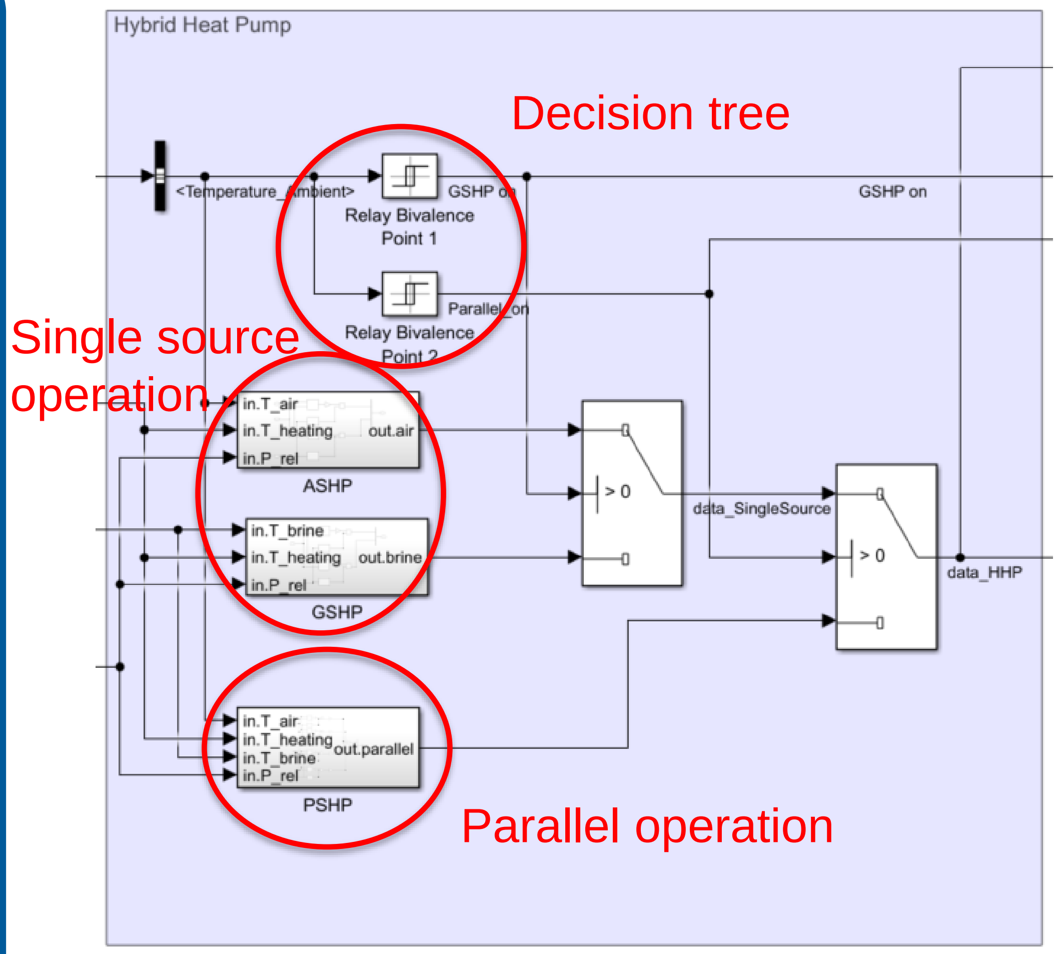
- **First tries with CARNOT heat pump model were difficult, because of the internal feedback of the heating temperature T_{sink}**



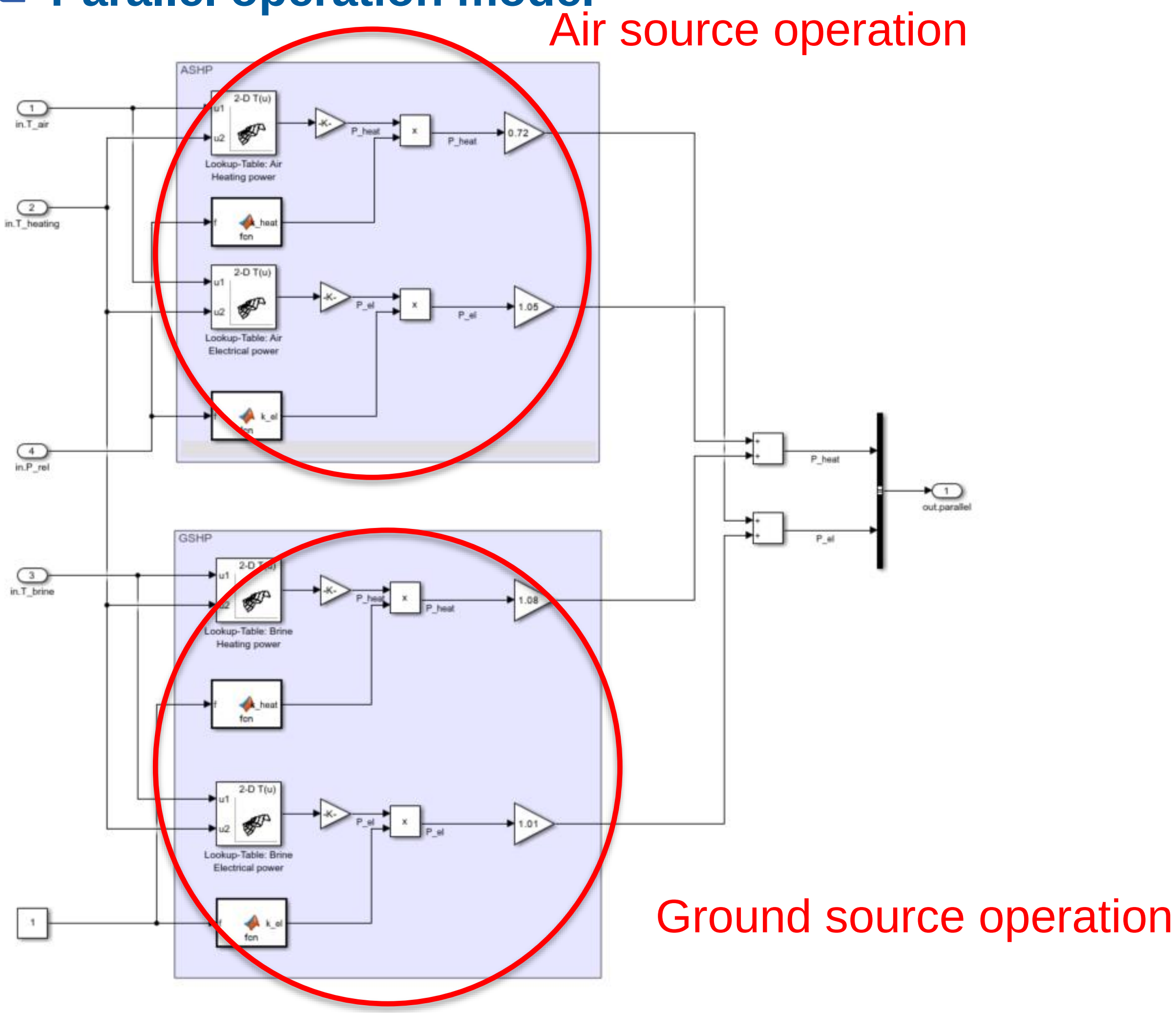
- **But T_{sink} needs to be calculated with the sum of both heating powers! → own solution for now…**

2. Modelling approach

- **Overall DSHP model**

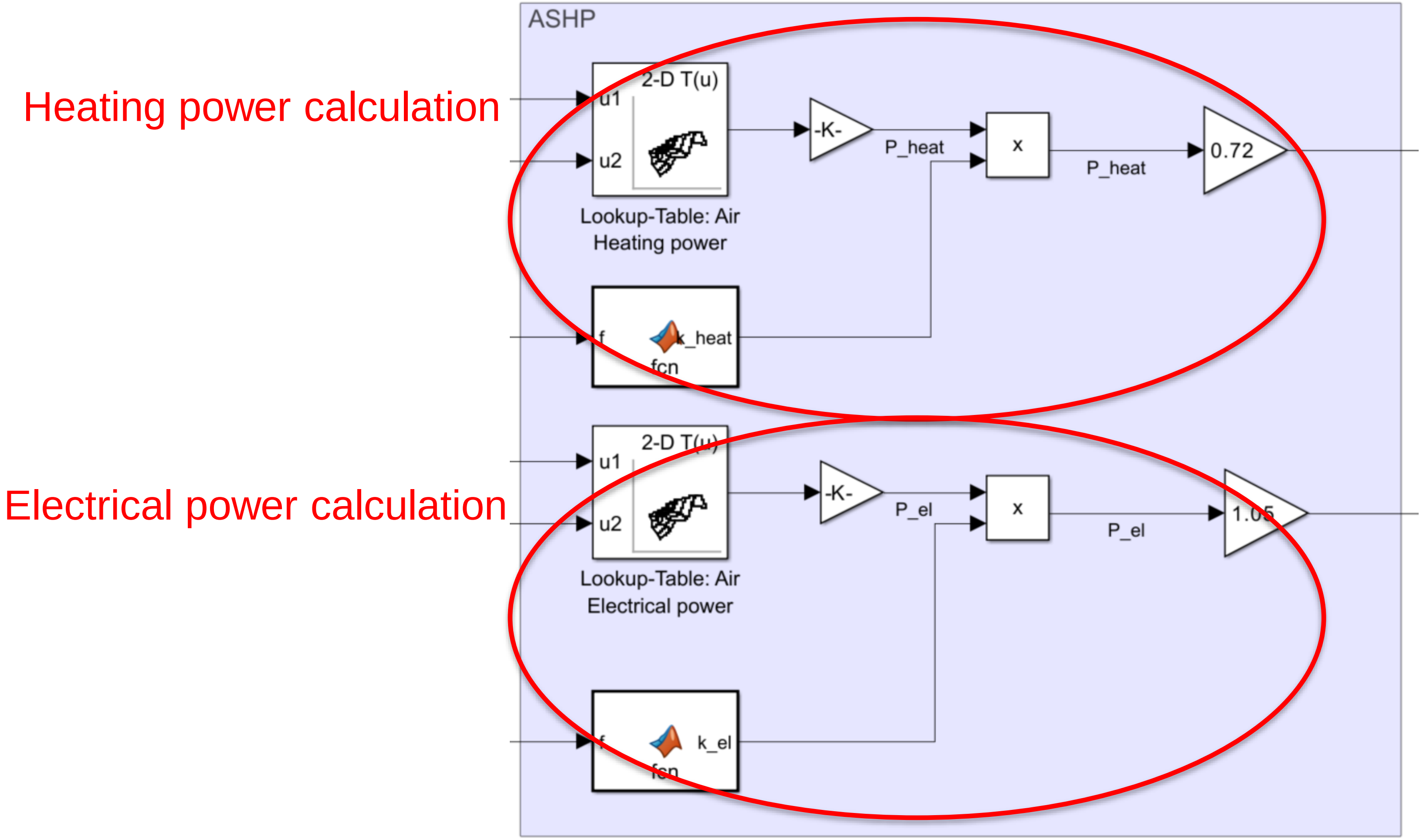


- **Parallel operation model**



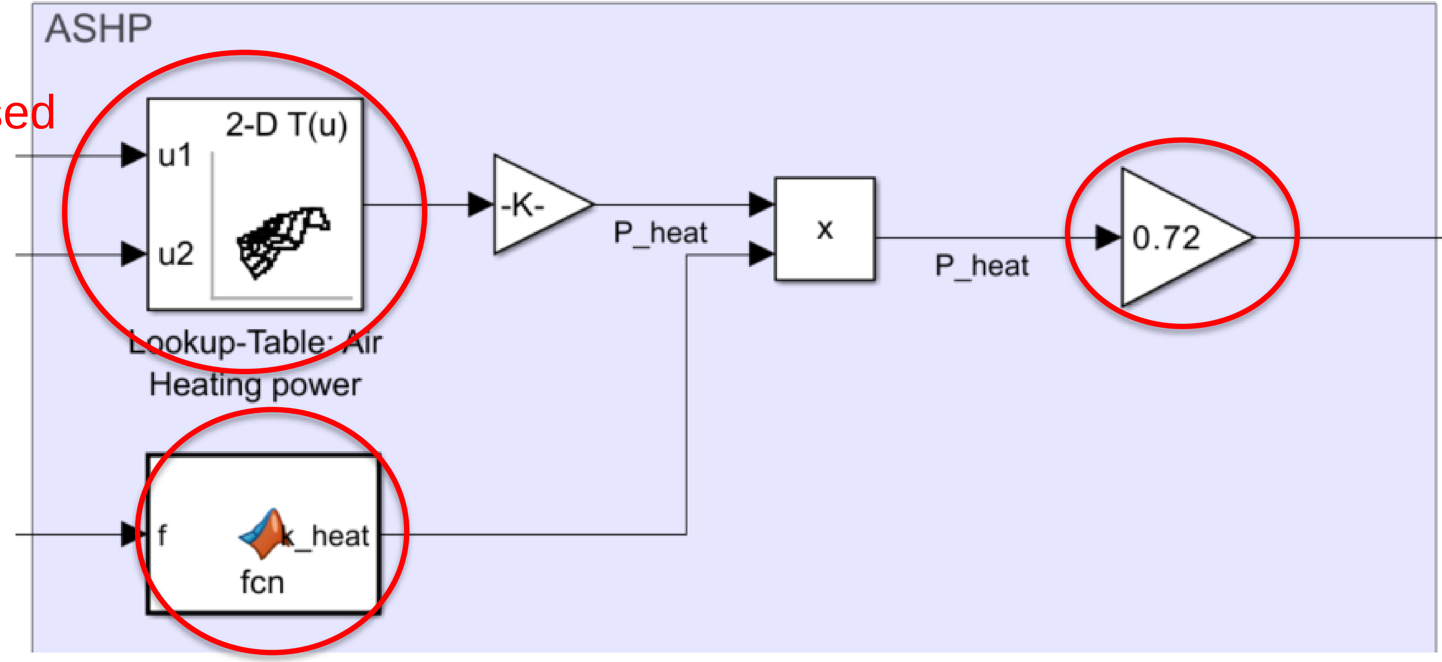
2. Modelling approach

- **Parallel operation: single air source operation plus correction factor f_{air}**



- **Parallel operation: single air source operation plus correction factor f_{air}**

Lookup table based on T_{air} and T_{sink}

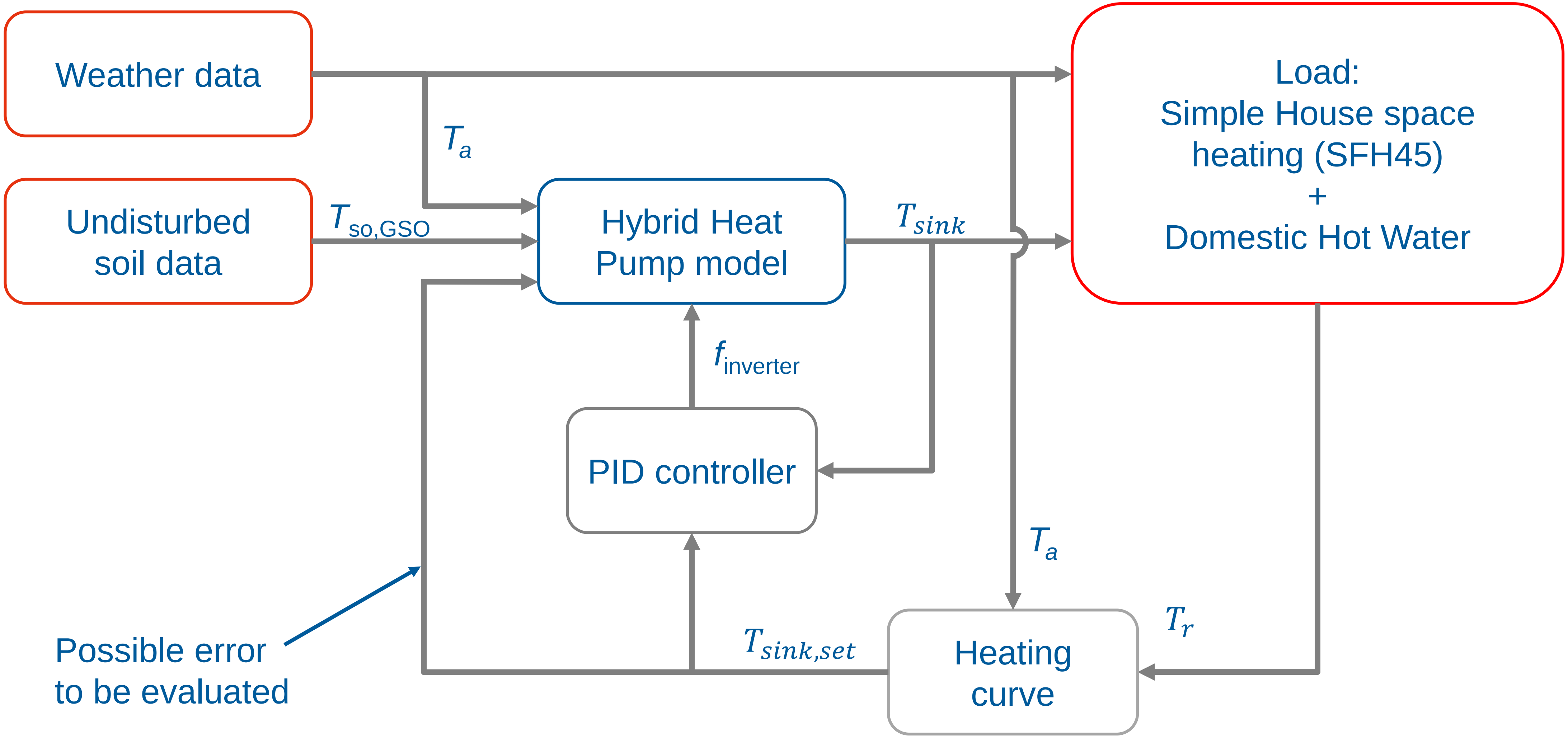


Correction factor based on comparing parallel source with combined single source operation; will become a function as well

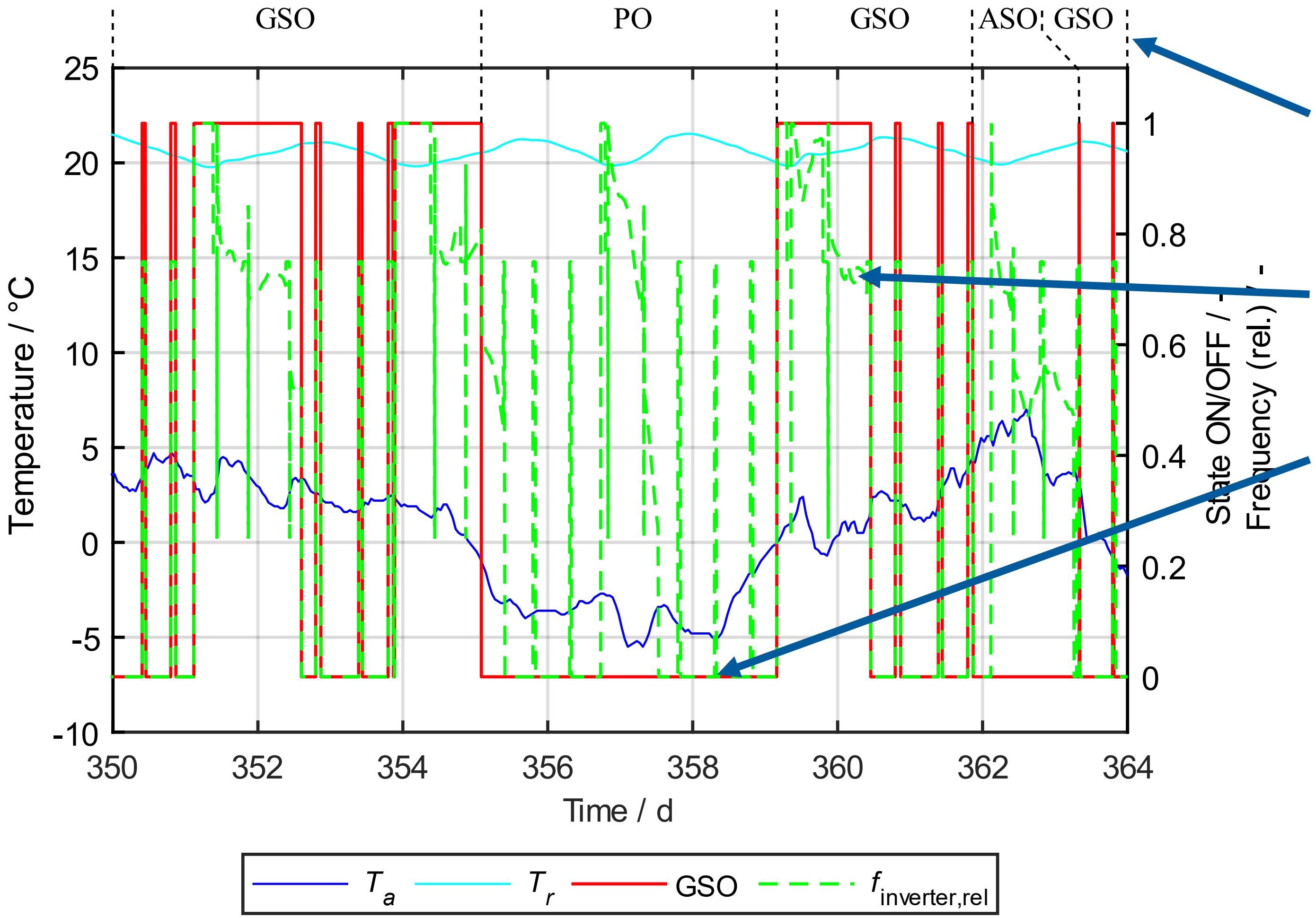
Non-linear correction factor for inverter impact

3. First results

Annual simulation



3. *First results*



1. **Switching between the operation modes worked according to T_a**
2. **Inverter control operated quickly and stable**
3. **PO activated at too high T_a: inverter reduces air source operation to minimum and T_r still overheats**
   → examine bivalence point 2 *according to ground source temperature/ time of the year/ room temperature/ inverter frequencies…*

Thank you for the attention!

Any remarks? Any questions?

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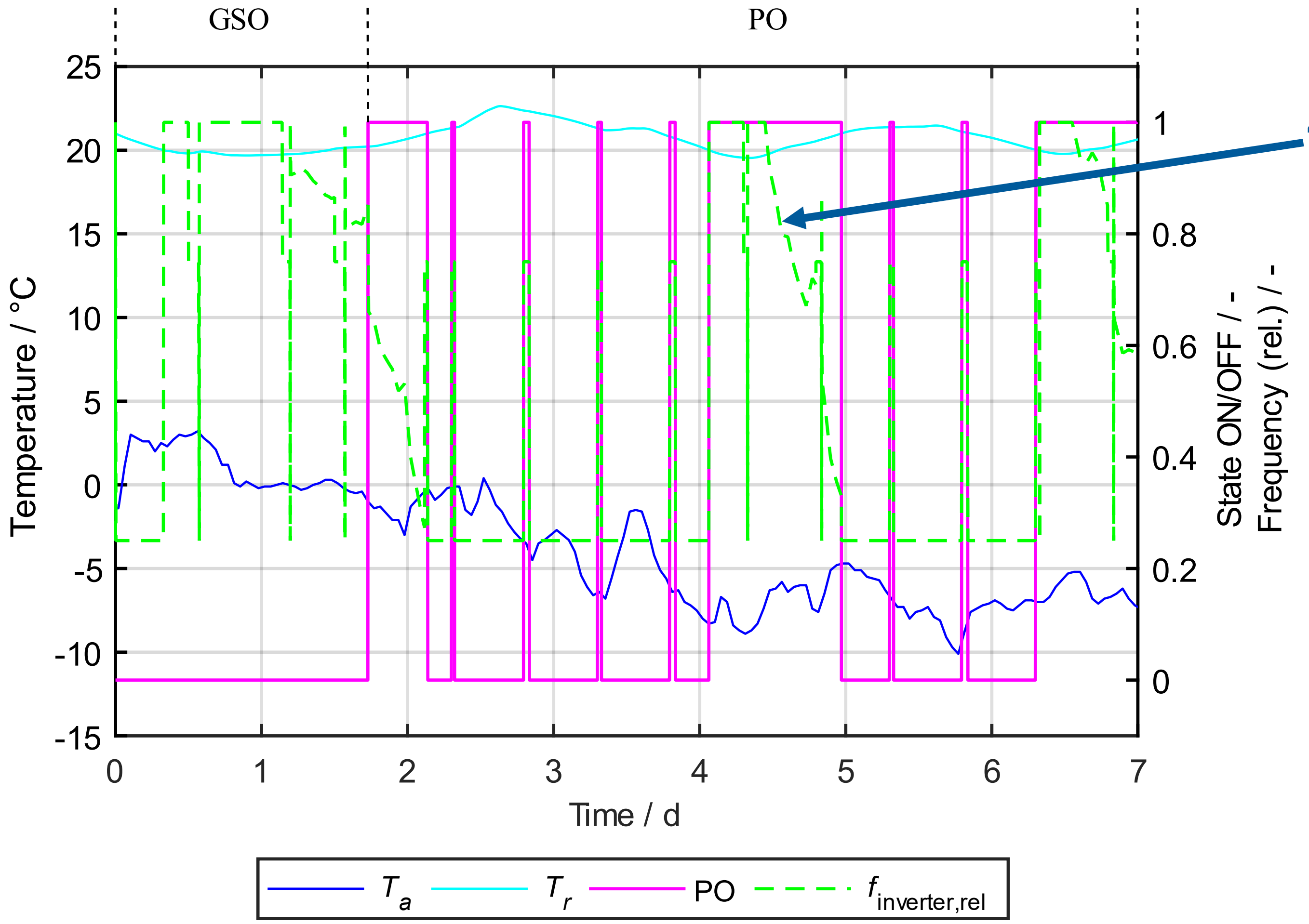
3. First results

SFH45 + DHW according to DIN EN 13203

Value	Unit	DSHP	GSHP
Heating energy	MWh	12.8	
Seasonal Performance Factor	-	3.34	3.50
Energy extracted from the GSHX	MWh	4.42	8.70
Cooling power on GSHX	kW	5.53	6.37

- **SPF decreases slightly by about 5 %**
- **Energy extracted from GSHX reduced to about 51 %**
- **Cooling power on the GSHX reduced to about 87 %**



4. PO activated properly at T_a: inverter controlled air source operation → examine bivalence point 2 *according to ground source temperature/ time of the year/ inverter frequencies*

First experiments – parallel operation

At ambient temperatures of -10 ° C:

$$COP_{GSHP} > COP_{DSHP} > COP_{ASHP}$$

But cooling power of the ground source:

$P_{DSHP} < P_{GSHP}$, to about 65 %