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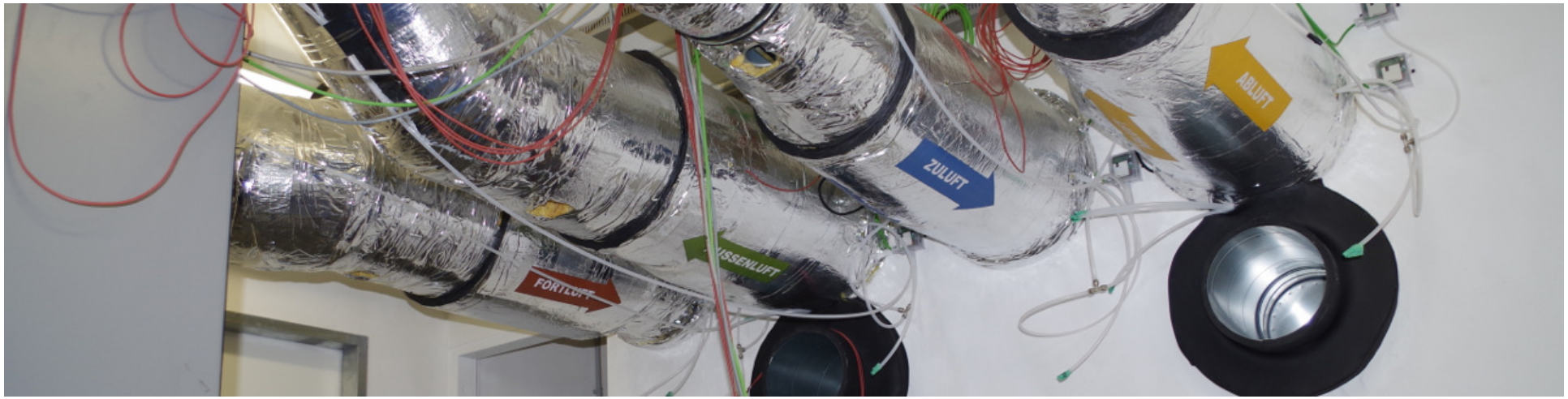
Energieeffizientes Bauen



Simulation assisted evaluation of the performance of a new generation heat pump compact unit

Ljubljana

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Objective

- Heating of a flat of a Multi-family Building with **decentral MVHR and heat pump compact unit**
- Evaluate
  - performance,
  - comfort and
  - IAQ
- Simulation Study
  - Reference System – Gas, HP (PHPP)
  - Dynamic Simulation of a Flat
    - Thermal Comfort
    - Indoor air quality (IAQ)
    - Performance
      - Heating
      - DHW

Src: Pichler Luft

Heat Pump Compact Units and Passive House

- Heat Pump Compact Units are widely used in Passive Houses (PH) since more than 20 yrs.
- Mainly in Single Family Houses (SFH)
- Little experience in Multi-Family Buildings (decentral, flat wise)
- Interesting Solution for New Passive Houses and EnerPhit renovations?

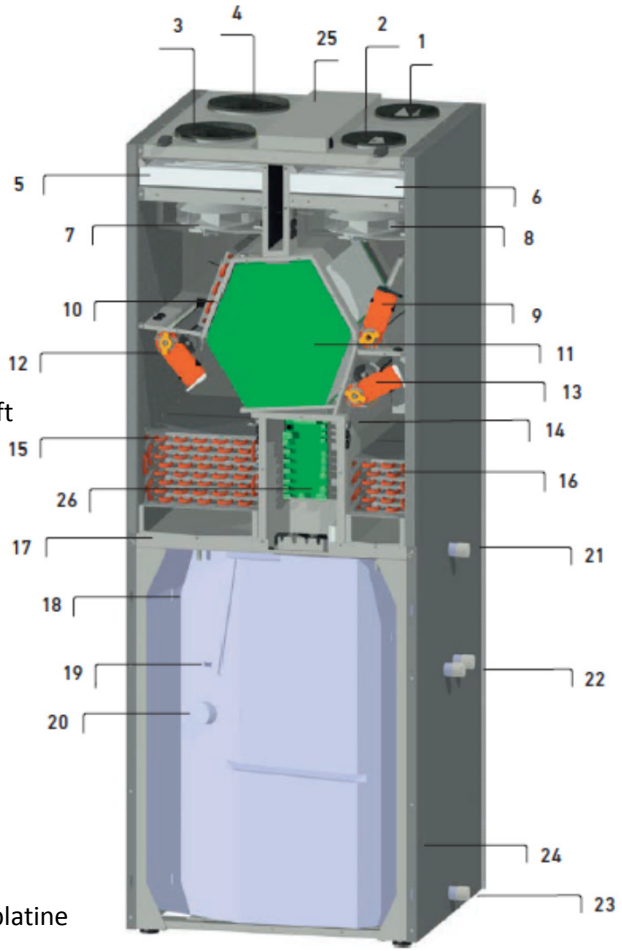
Src: Pichler Luft

New GenerationCompact Unit

» PKOM^4 (Pichler Luft)

- Mechanical Ventilation with Heat Recovery (HRV)/Enthalpy Recovery (**ERV**)
  85 m³/h – 250 m³/h (variable)
  η_T = 88 % (HRV)
- Exhaust/Supply Air Heat Pump for Heating with **1.3 kW** (A2, V_{max}) and cooling
- DHW heat pump with **212 l** buffer store and heating capacity of **1.6 kW** (exhaust air 160 m³/h with additional ambient air (120 m³/h)
- Additional bathroom radiator for comfort reasons

1 Zuluft
2 Abluft
3 Außenluft
4 Fortluft
5 Außenluftfilter F7
6 Abluftfilter M5
7 Außenluftventilator
8 Abluftventilator
9 Bypassklappe mit Stellmotor
10 Vorheizregister für die Außenluft
11 Gegenstromwärmetauscher
12 AUL/FOL Klappe mit Stellmotor
13 AUL/ZUL Klappe mit Stellmotor
14 Verdichter in Einhausung
15 Wärmetauscher in Fortluft
16 Wärmetauscher in Zuluft
17Kondensatwanne
18 Brauchwasserspeicher
19 Opferanode
20 Elektroheizstab mit STB
21 Warmwasseranschluss 1“AG
22 Heizregisteranschluss 1“AG
23 Kaltwasseranschluss 1“AG
24 Kondenswasser Abfluss
25 Elektroanschlussbox mit Hauptplatine
26 Wärmepumpenplatine



Src: Pichler Luft

PKOM^4 and PHPP (PHI certified)

Heating

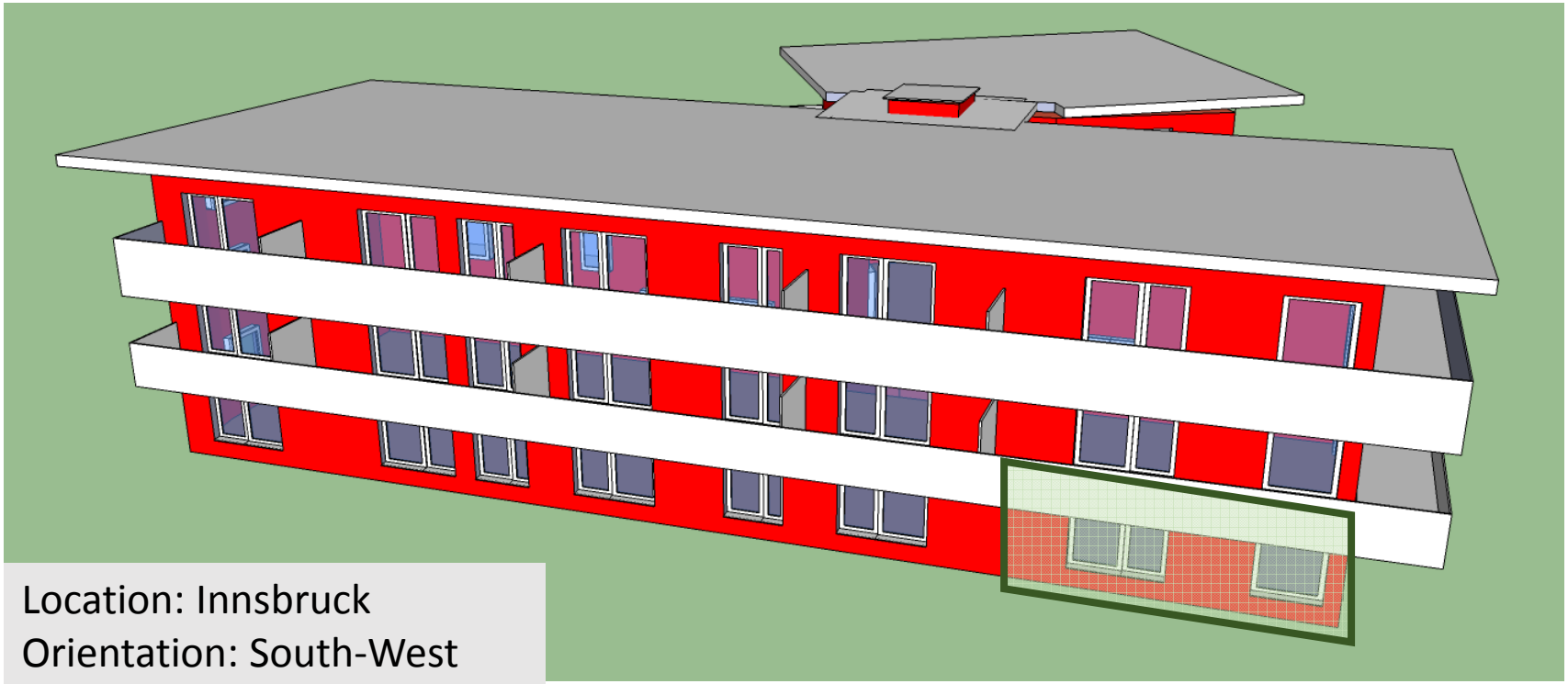
		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	-15	-7	2	7	°C
Thermal Output Heating Heat Pump	$P_{WP,Heiz}$	0.612	0.933	0.771	0.776	kW
COP number Heating Heat Pump	COP_{Heiz}	1.53	2.61	3.15	3.86	-
Maximum available supply air temperature with Heat Pump only(*)		35				°C

Hot water

		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	-7	2	7	20	°C
Thermal Output Heat Pump for heating up storage tank.	P_{DHW} heating up	0.84	1.15	1.38	1.67	kW
Thermal Output Heat Pump for reheating storage tank	P_{DHW} reheating	0.80	1.19	1.35	1.66	kW
COP Heat Pump for heating up storage tank	$COP_{DHW,}$ heating up	2.28	2.97	3.34	3.94	-
COP Heat Pump for reheating storage tank	COP_{DHW} reheating	2.02	2.88	3.10	3.76	-
Average storage tank temperature		45				°C
Specific storage heat losses		1.51				W/K
Exhaust air addition (if applicable)		200				m³/h

src: Zertifikat Passivhausinstitut

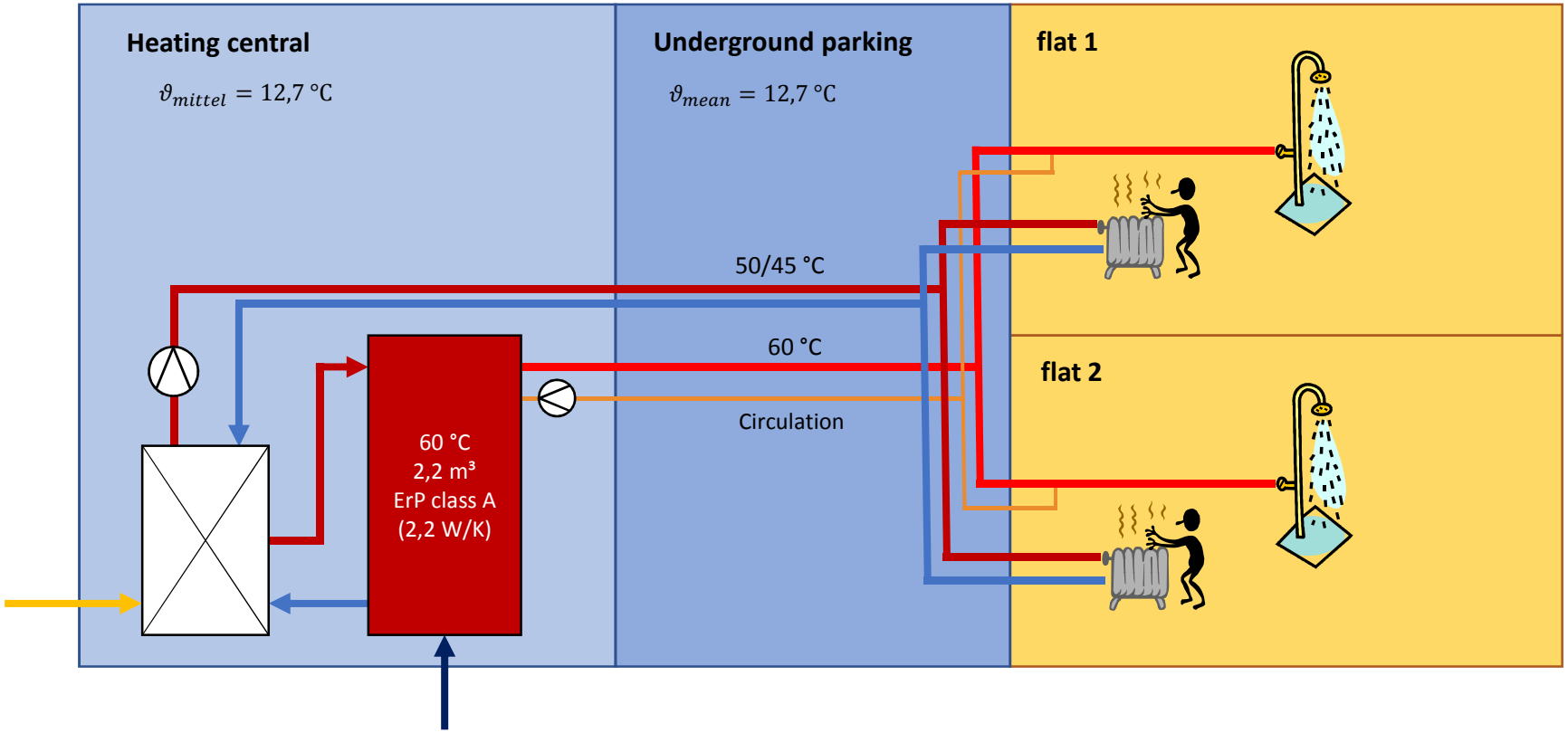
Simulation object



Location: Innsbruck
Orientation: South-West
Treated Area: 1941,4 m²
Occupation: 54 Persons

Sketchup, Design PH

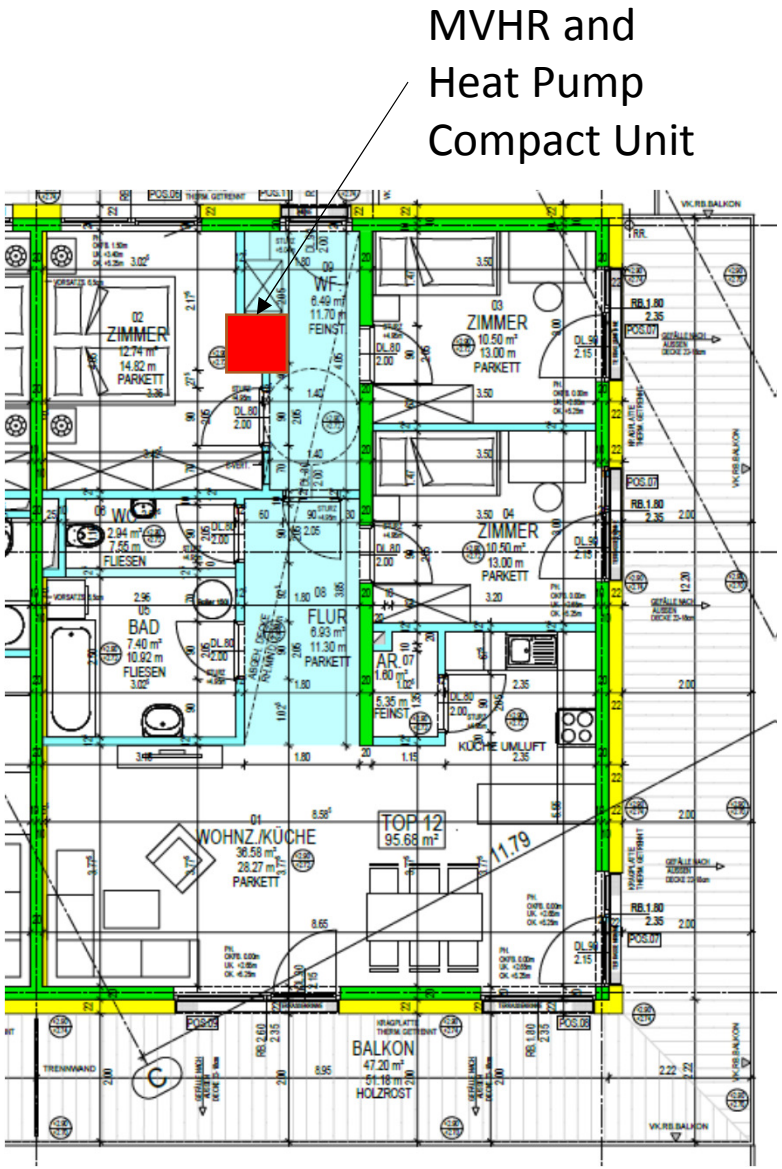
Reference: Central MVHR and Heating System



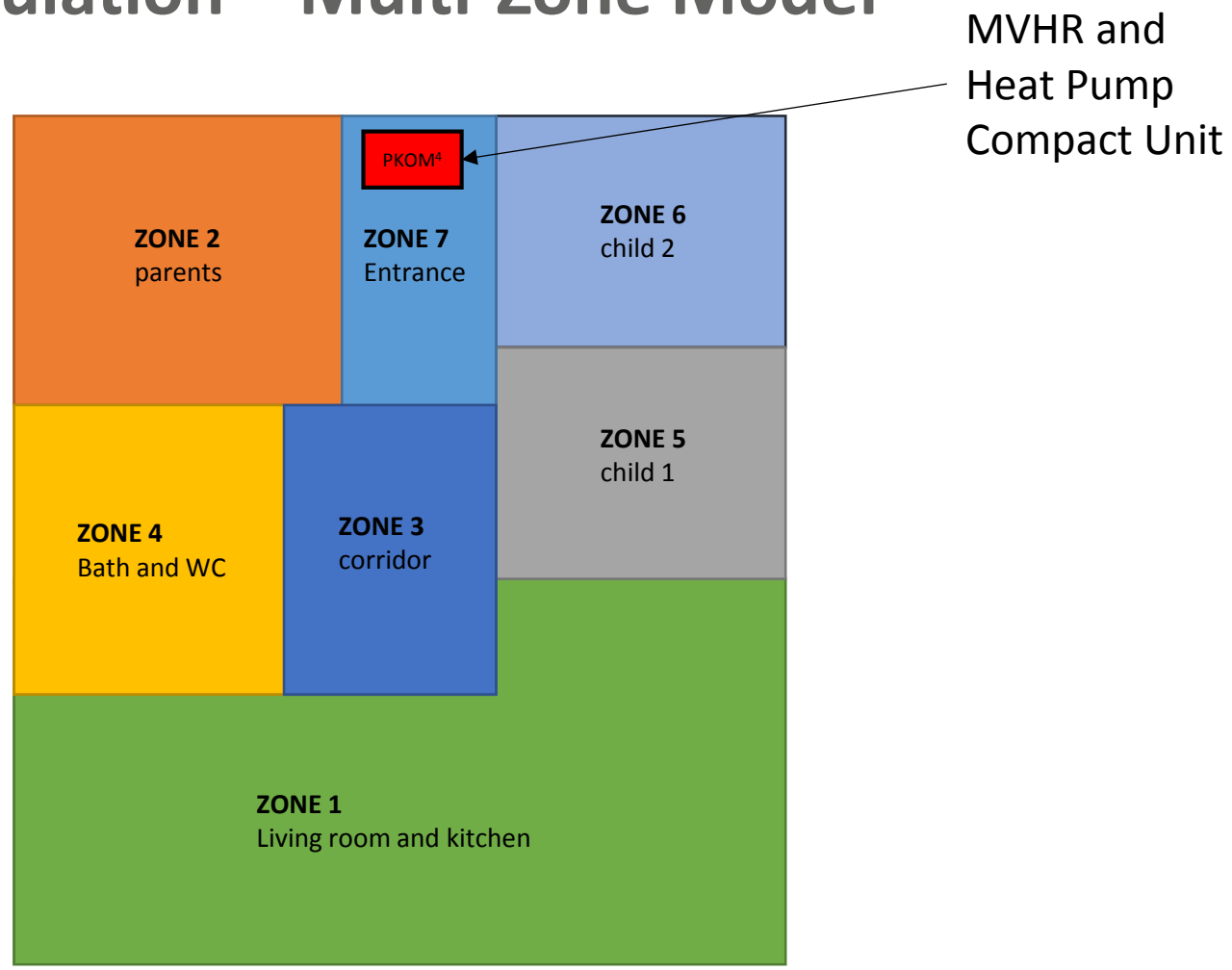
MVHR: mechanical ventilation with heat recovery

Simulation object (cont.)

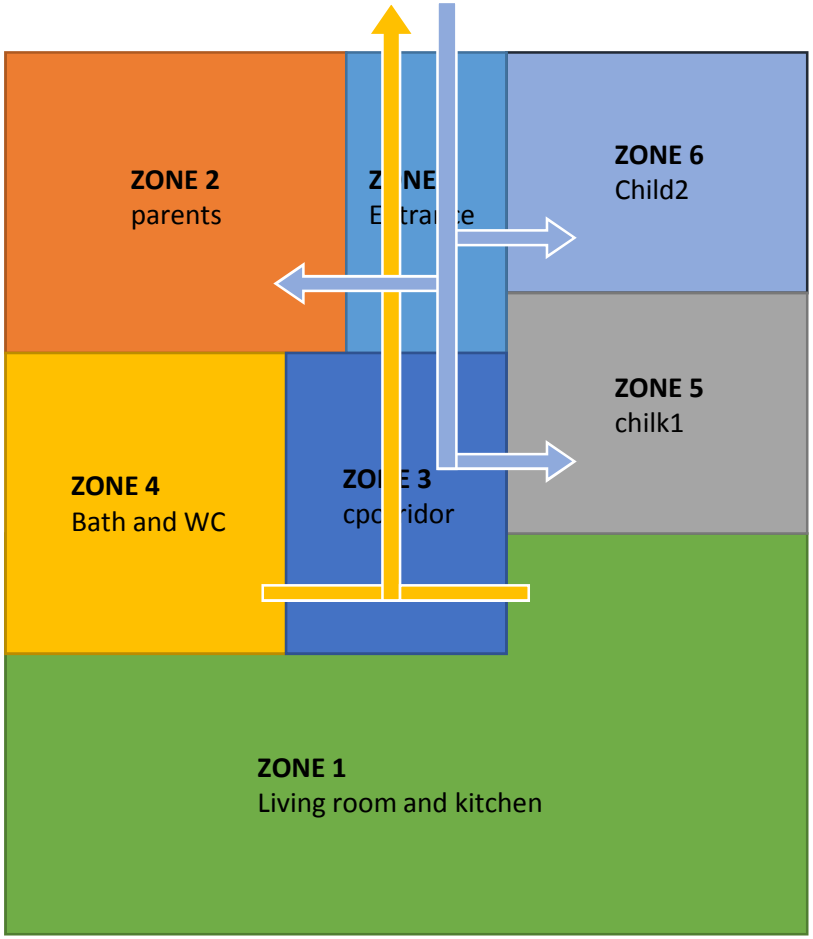
- Flat oriented South-West
  - 99.90 m² treated area
  - Ground floor adjacent to unheated cellar
  - Flat with highest heating load
- Occupation
  - 4 Persons



Building Simulation – Multi-Zone Model



Building Simulation –
Reference System: central MVHR, Gas Boiler

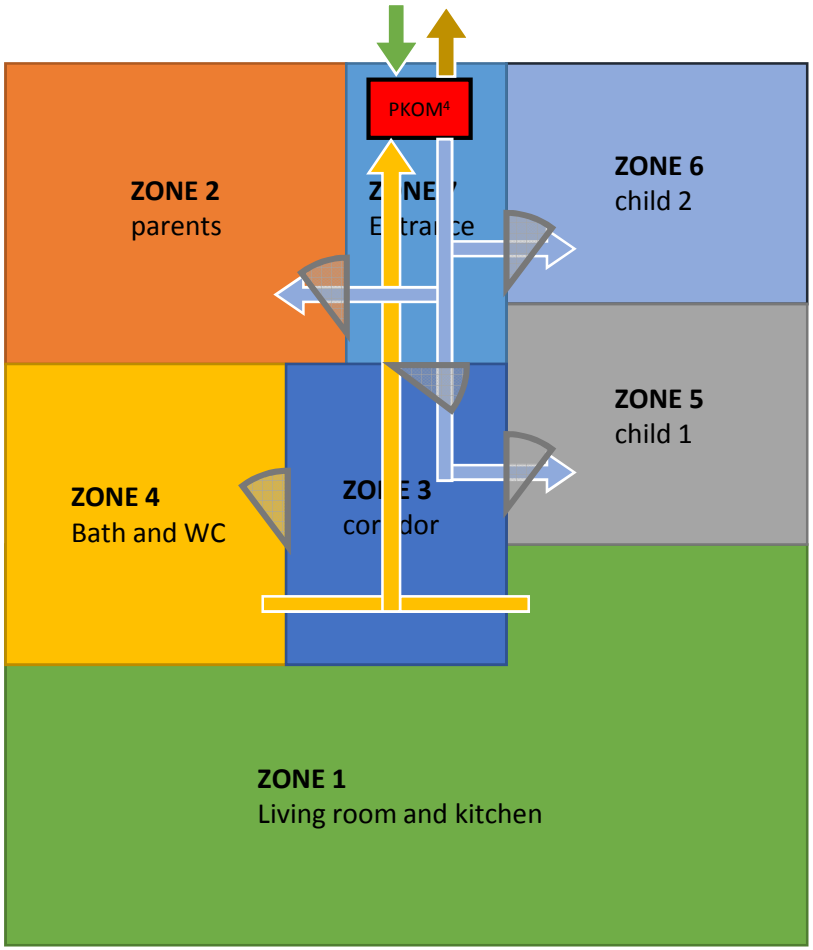


Cascade ventilation

Volume flow:

- 120 m³/h
- 80 m³/h

Building Simulation PKOM^4 - Heating



Ventilation: Case 1

Cascade Ventilation

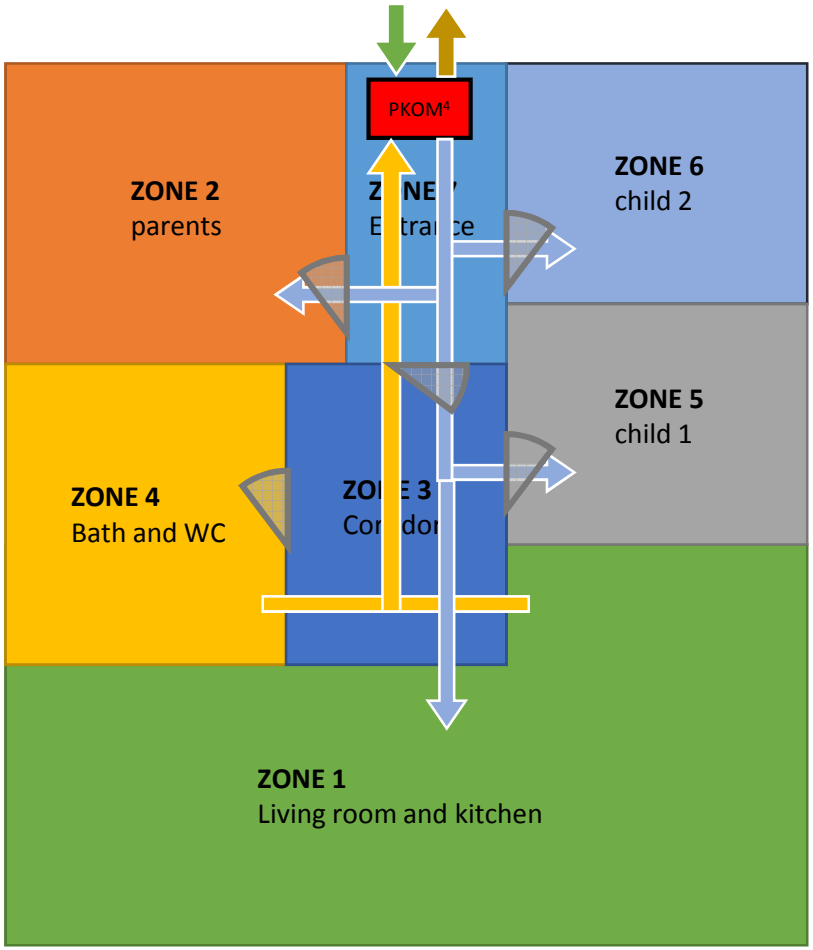
Volume flow:

- 120 m³/h or **160 m³/h**

Door position

- all open

Building Simulation PKOM^4 - Heating



Ventilation: Case 2

Classic Ventilation

Volume flow:

- 120 m³/h or **160 m³/h**

Door position

- all open
- all closed

Results PHPP – Building

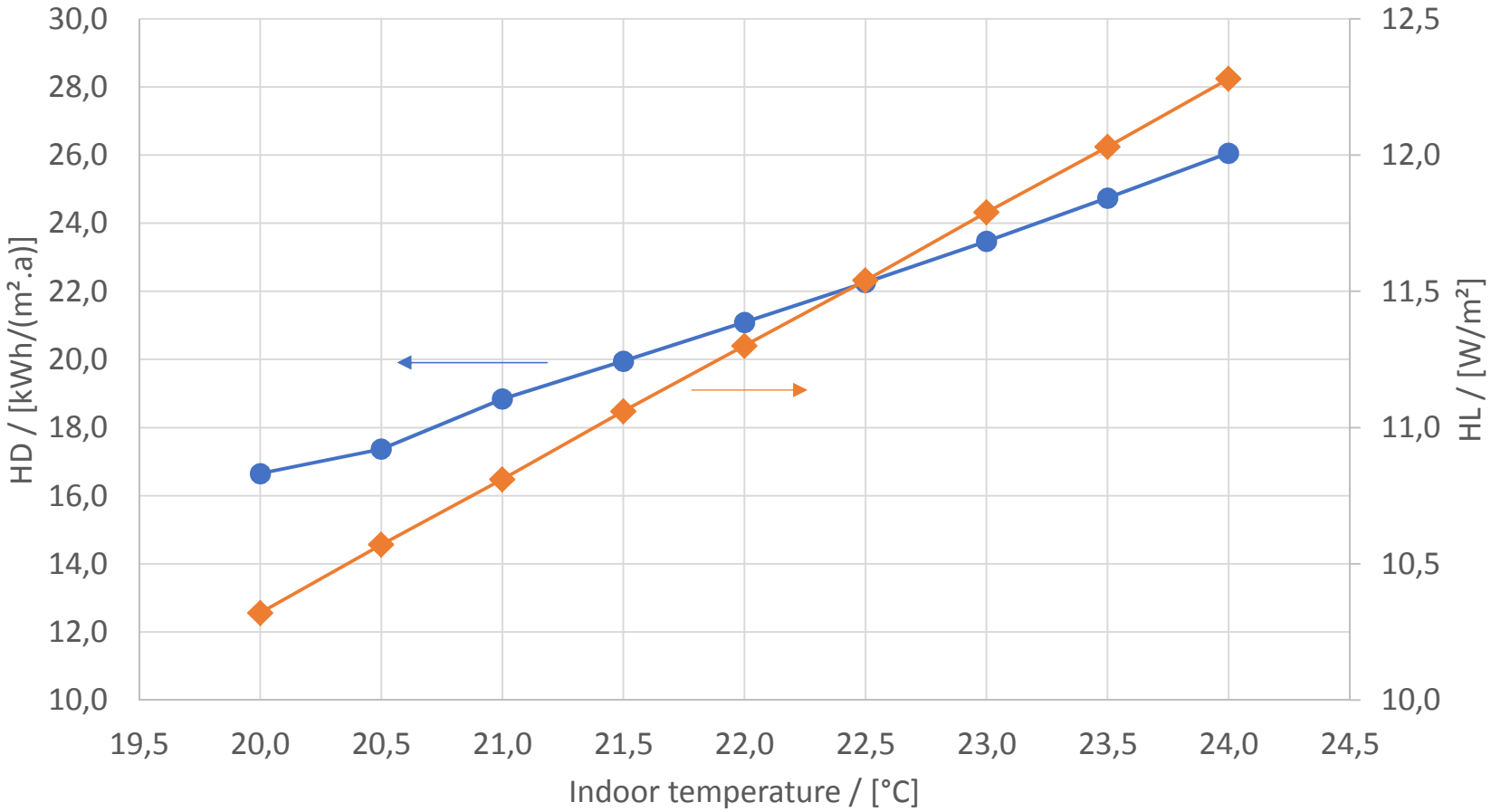
» Heating Demand (at 20°C)
  - 16.6 kWh/(m².a) **32 233 kWh/a**

» Heating Load
  - 10.30 W/m² (bei 20°C) 20.0 kW (building)
    1.0 KW (flat)

» Duration of Heating Period: 210 days

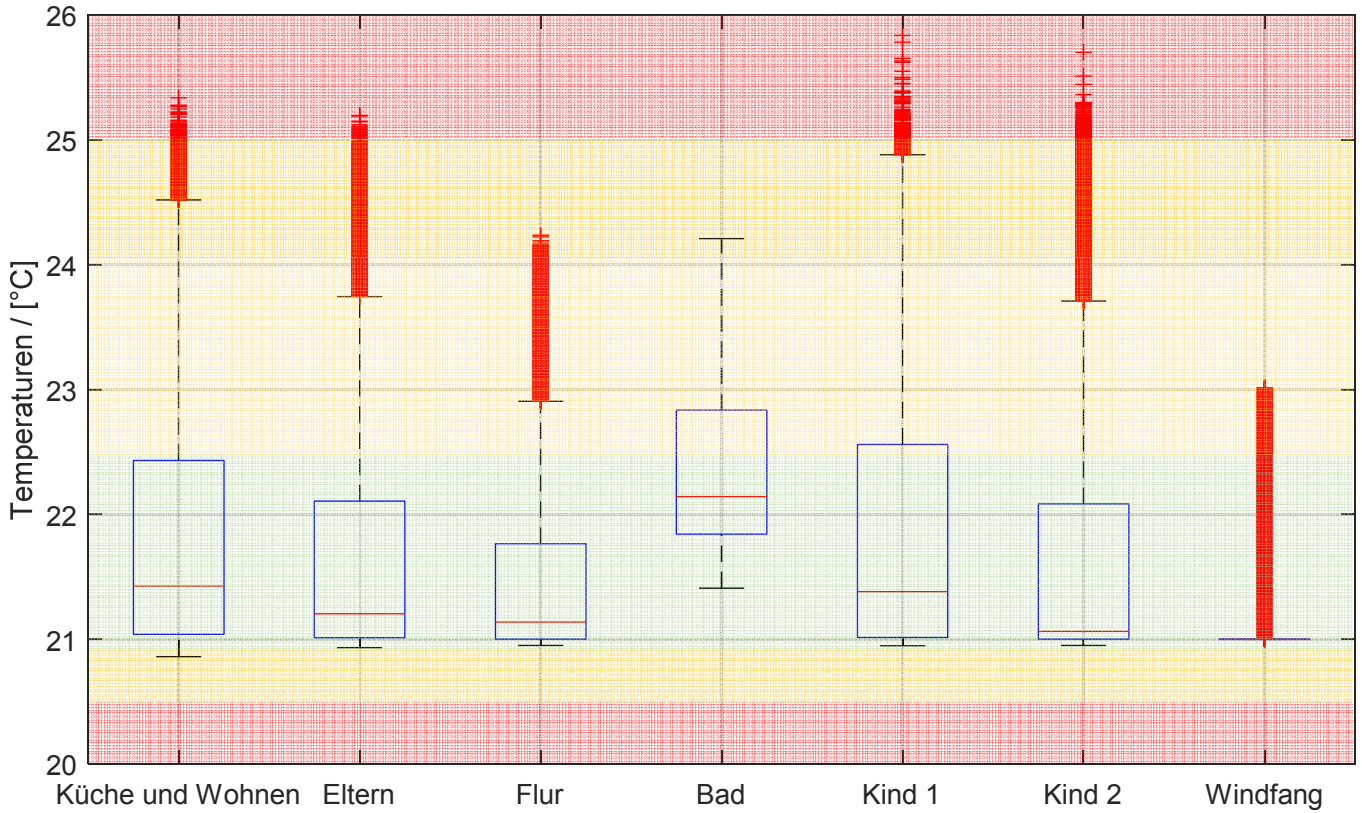
» Hot water Demand
  - 14.65 kWh/(m².a) **28 447 kWh/a**

Results Heating Load and Heating Demand (PHPP)



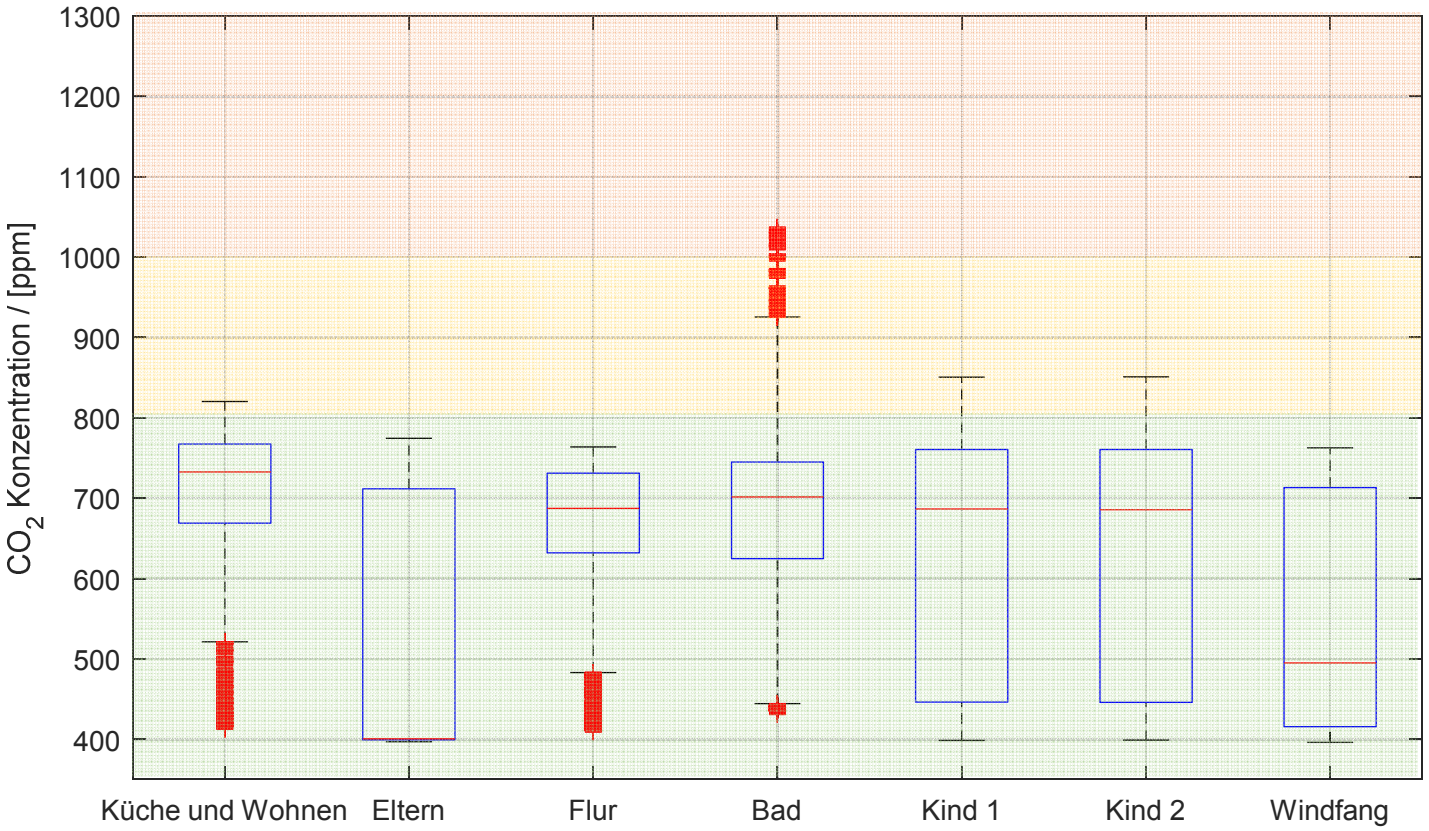
Results Reference Gas - Heating

Temperature



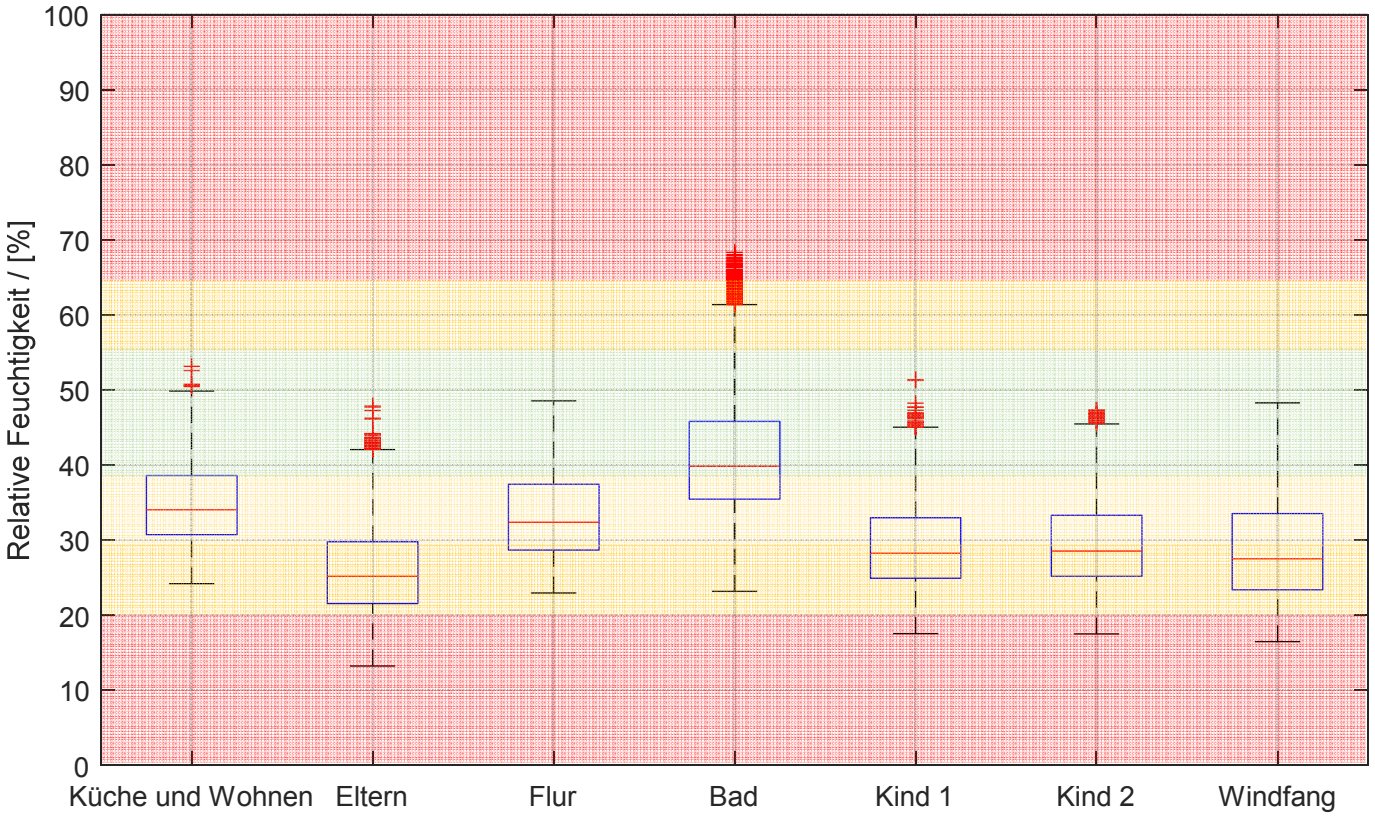
Results Reference Gas - Heating

Cascade: 120 m³/h



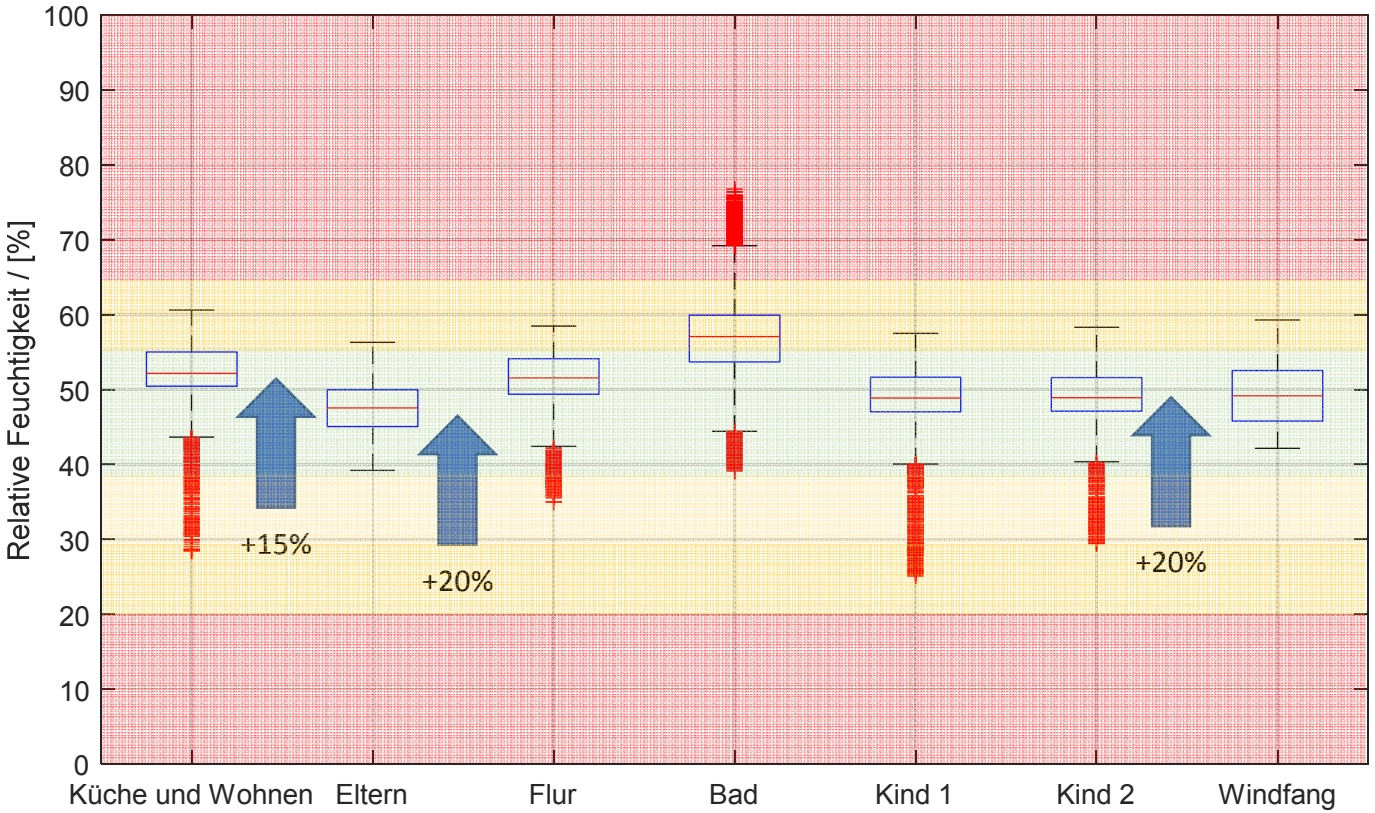
Results Reference Gas - Heating

120 m³/h
Heat recovery (HRV)



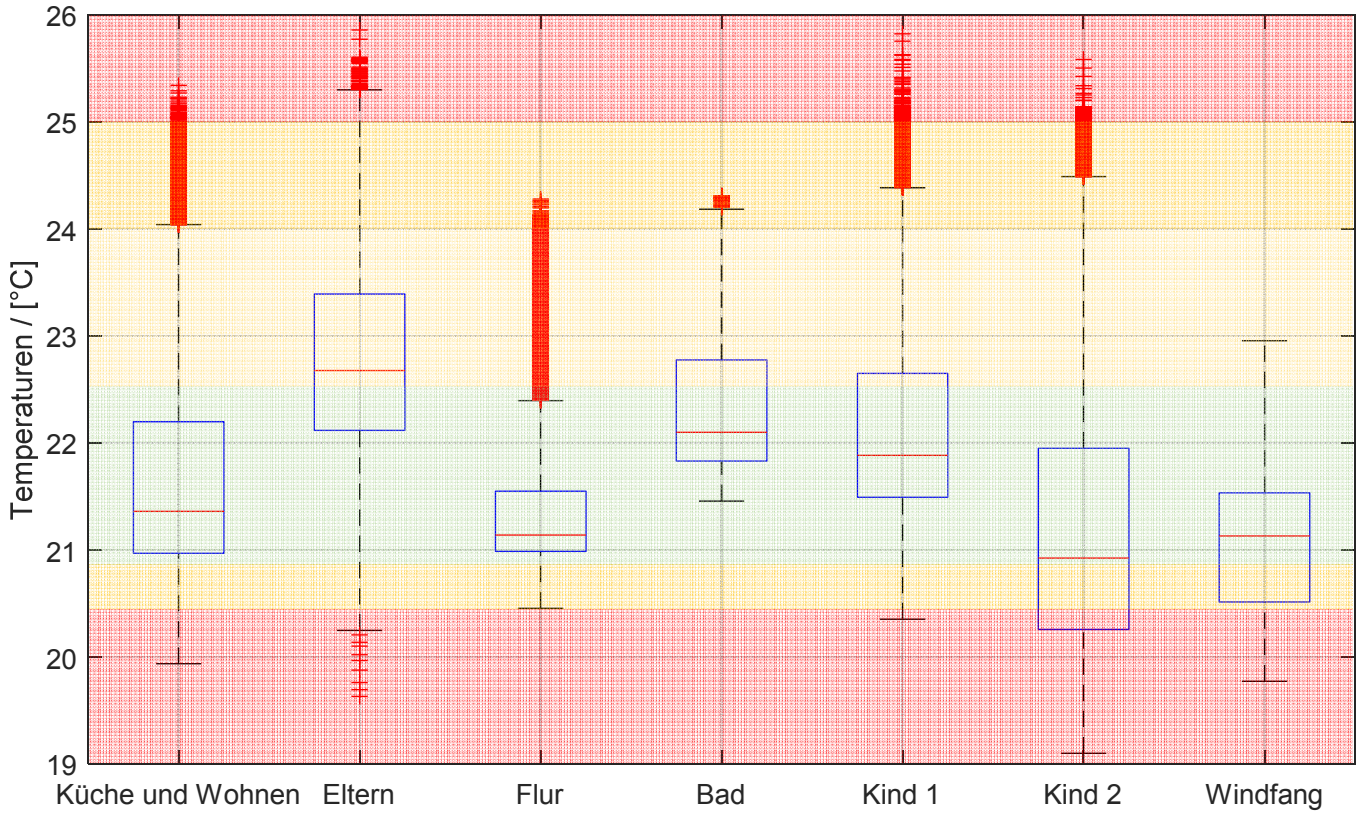
Results Reference Gas - Heating

120 m³/h
moisture recovery (ERV)



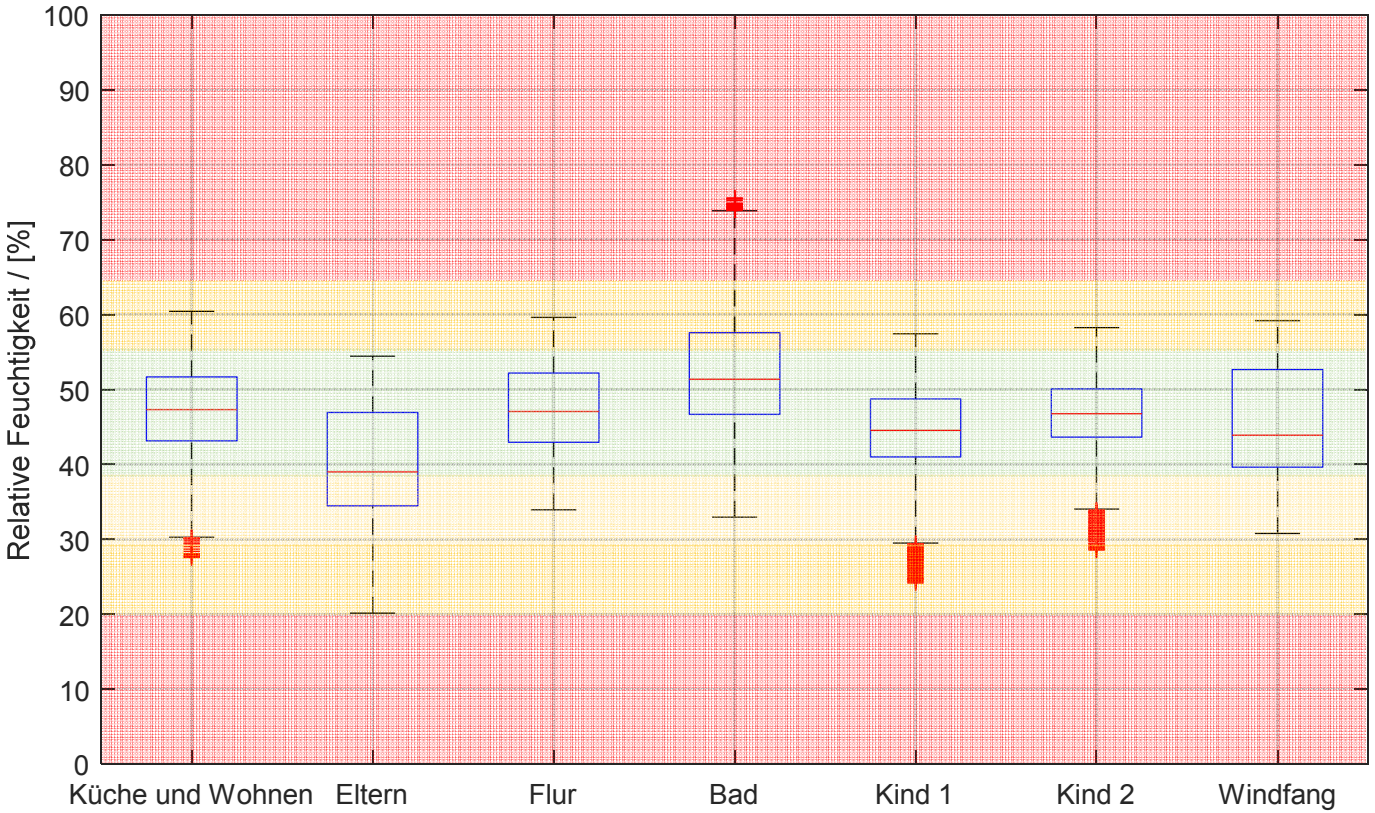
Results decentral heating PKOM[4]

Case 2 with ERV
Doors closed



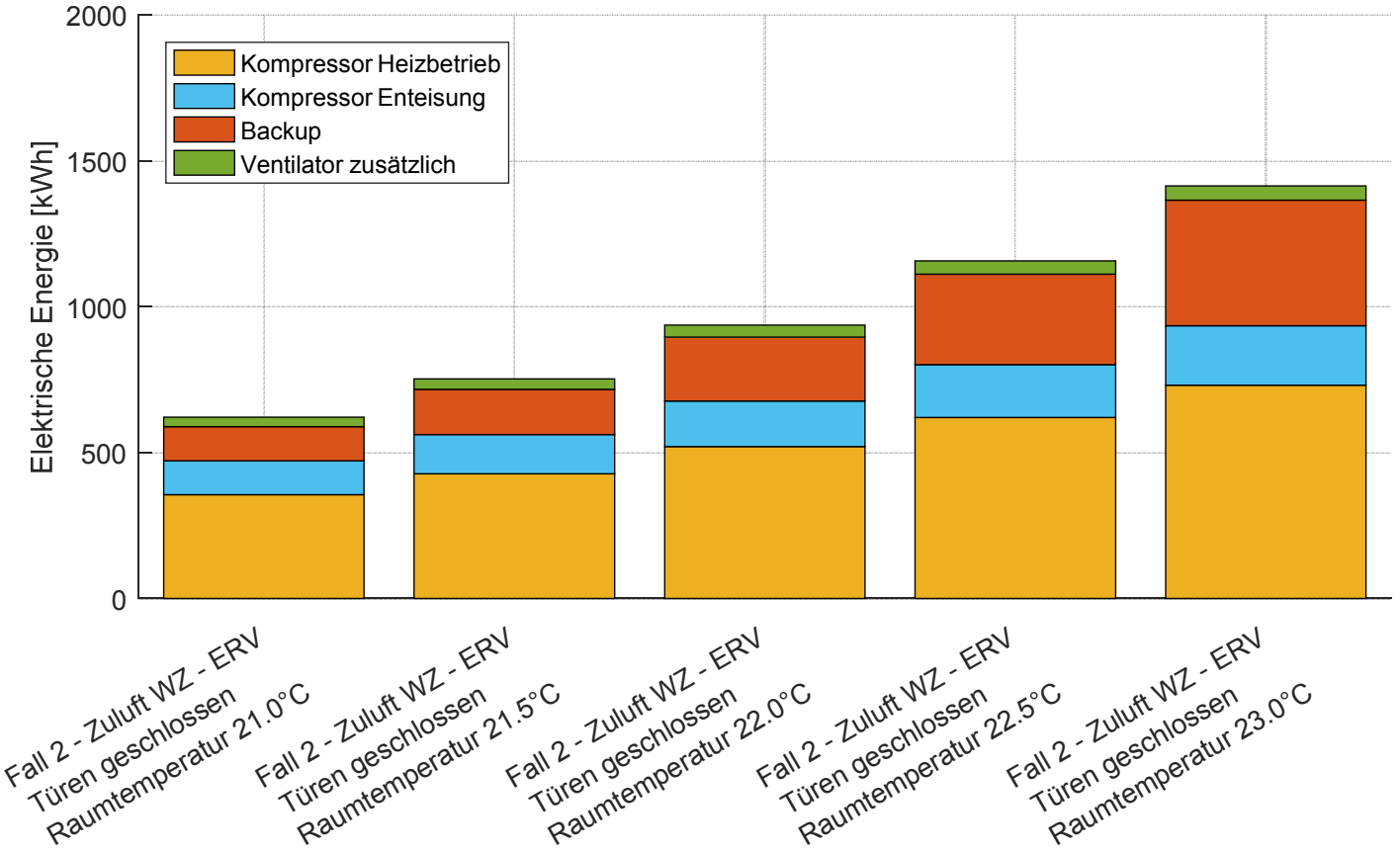
Results decentral heating PKOM^4

Case 2 with ERV
Doors closed



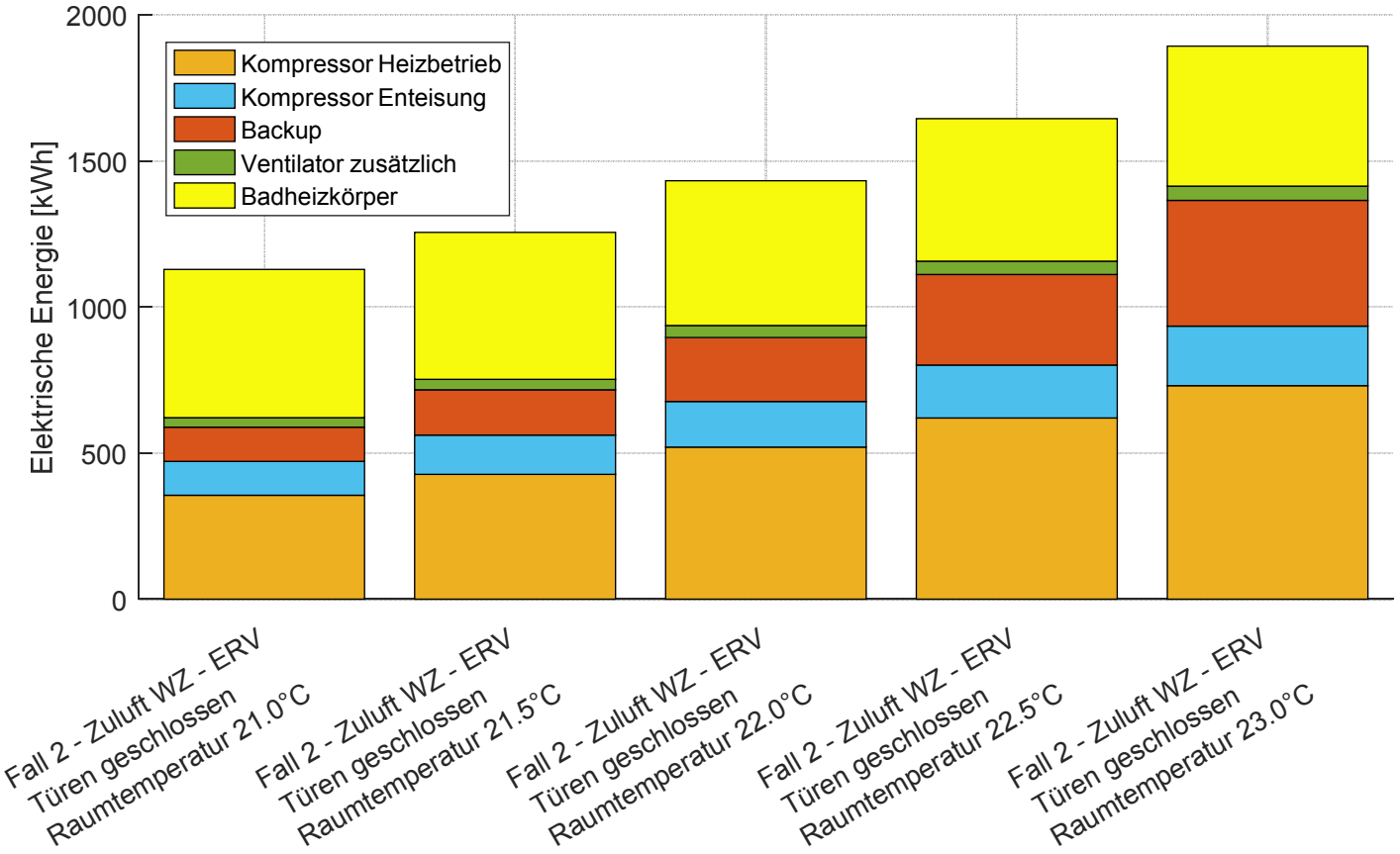
Results decentral heating PKOM[4]

Electricity Demand ERV



Results decentral heating PKOM[4]

Electricity Demand
ERV with post-heater



Results Reference Gas – Domestic Hot Water

» Expanditure Factor ($e_p = 1/\eta$) DHW
- Heat Generation: 105 %
- Storage, Distribition and cirkulation: 187 % (total)
  173 % (excluding gains from pipes inside thermal envelope in heating period*)

» **End energy demand DHW with (central) Gas**

53 3 kWh/a (*49.3 MWh)

- Useful DHW: 28.5 MWh/a
- Losses Distribution: 25 .0 MWh/a (*21 MWh)

Effective SPF (including losses) with central HP

» $Q_{use,DHW}$ Useful DHW

» $Q_{tot,DHW}$ DHW + Losses

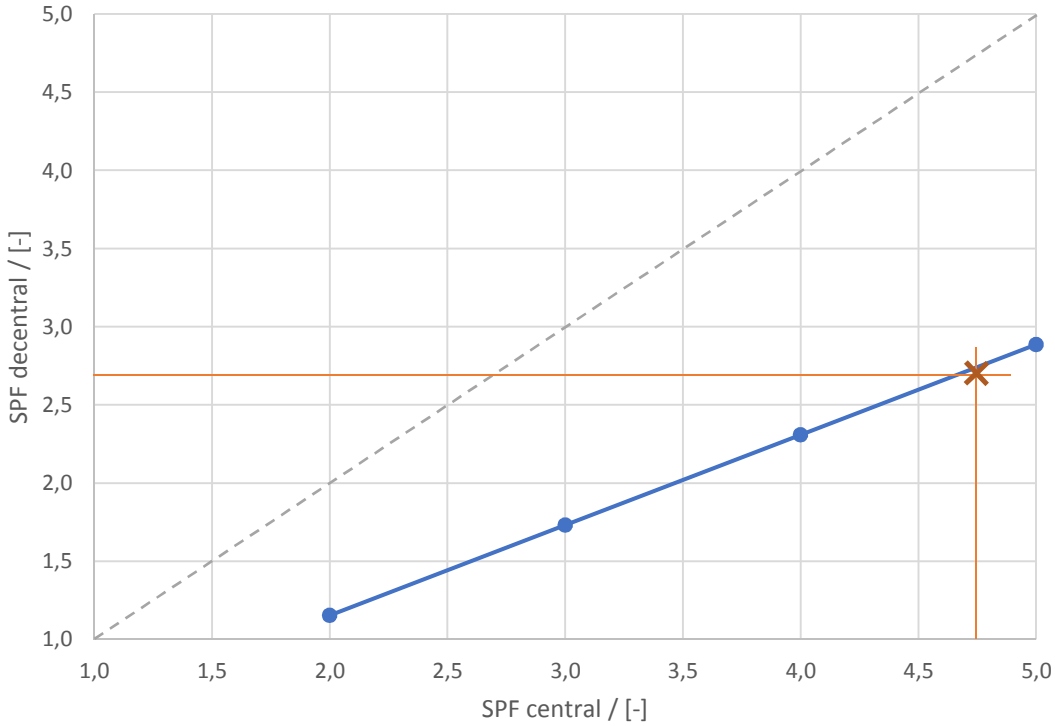
Example:

$SPF_{zentral}$ = 4.75

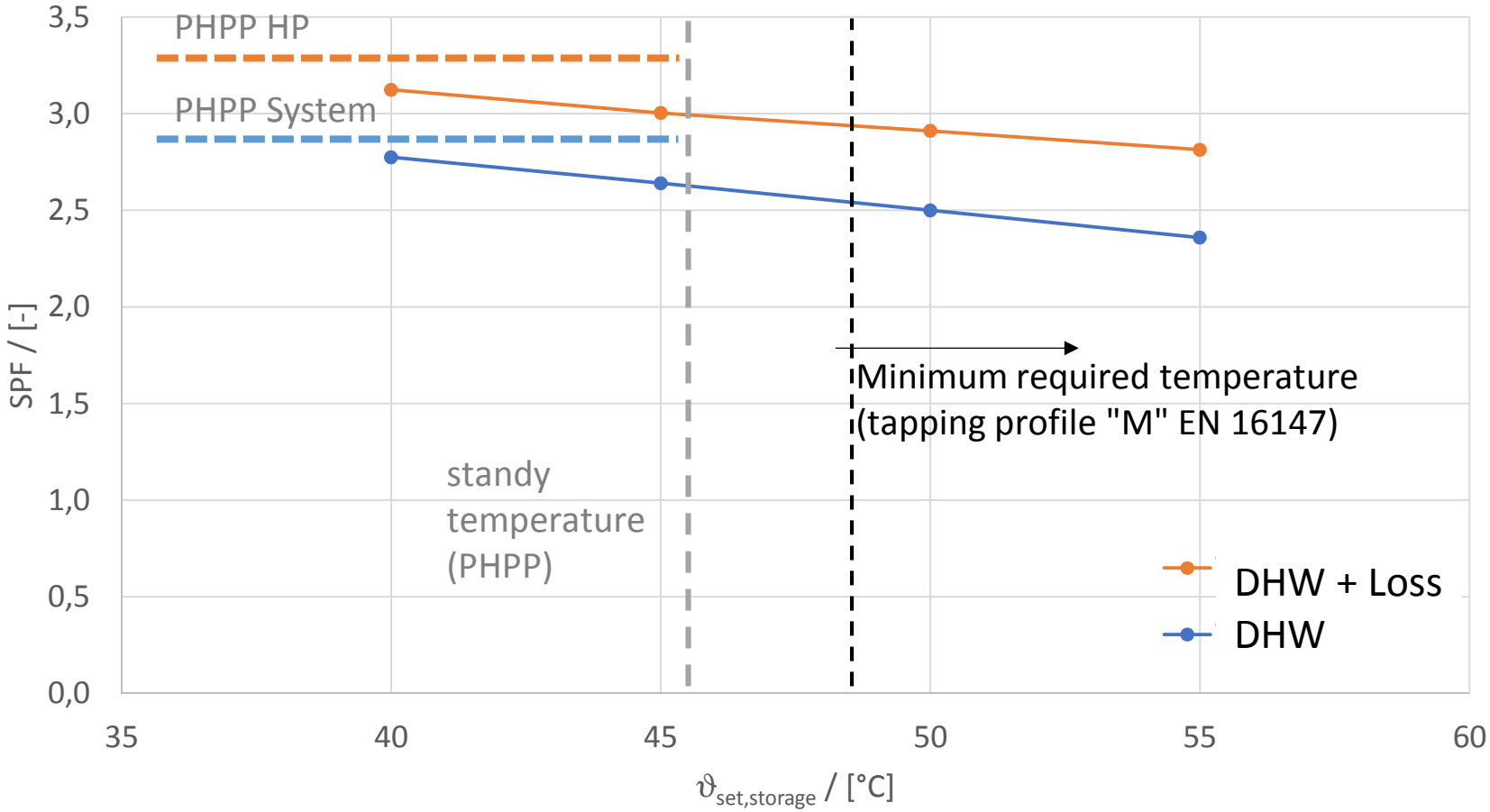
$SPF_{dezentral}$ = 2.7

w_{el} = 5.35 kWh/(m².a)

W_{el} = 10.4 MWh



Results PKOM^4 – Domestic Hot Water Preparation



Summary and Conclusion

- Heating and DHW preparation in Passive House Multi-Family Buildings
- Detailled Building and HVAC simulation of a **MVHR and heat pump compact unit** in comparison to central heating system (reference)
- Low influence of **ERV**/HRV on efficiency
  - But significant **better IAQ/comfort**!
- **Good performance** (i.e. low operation costs) of decentral HP compact unit ($SPF_{heating}$ = 2.5, $SPF_{DHW,sys}$ = 2.8)

Summary and Conclusion

- **Demand-oriented volume flow control** recommended to avoid
  - under-heating in kitchen and living room,
  - over-heating in sleeping rooms
- **Post-heater** for better comfort (in bathroom) and individual room control (in corridor, living room)
  - Robust control required,
  - risk of performance drop with electric heater,
  - Better performance with **additional hydronic loop** from DHW store

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