Energy refurbishment of residential buildings of the 50s – research and results

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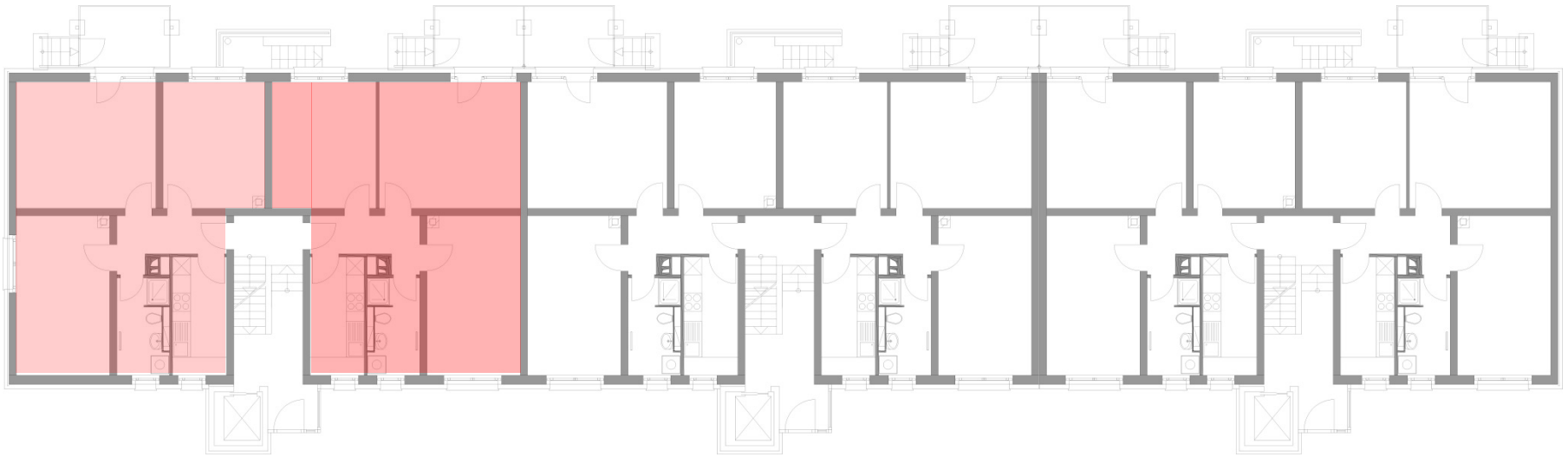
Initial situation

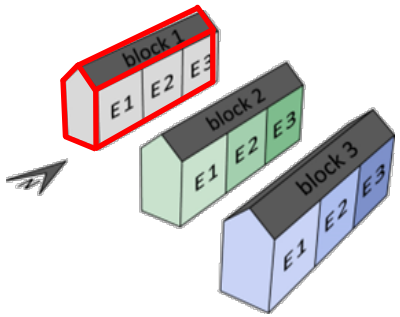


Entrance E1 Entrance E2 Entrance E3

Retrofit layouts: Block 1 „Standard“

Structural retrofit

Facade:	14 cm insulation 0.035 W/(mK)	→ U = 0.22 W/(m²K)
Window:	double glaze	→ U = 1.3 W/(m²K)
Top floor:	16 cm insulation 0.035 W/(mK)	→ U = 0.21 W/(m²K)
Basement:	7cm insulation 0.035 W/(mK)	→ U = 0.31 W/(m²K)



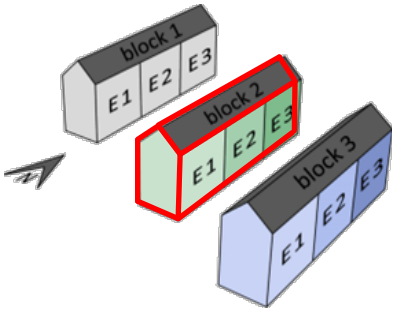
Engineering system retrofit

Heating:	district heating, compact radiators
DHW:	decentral low temperature DHW heat exchanger
Ventilation:	exhaust air system, windows frame openings

Retrofit layouts: Block 2 „3 liters home“

Structural retrofit

Facade:	16 cm insulation 0.021 W/(mK)	→ U = 0.11 W/(m²K)
Window:	double/triple glaze	→ U = 1.3 /0.8 W/(m²K)
Top floor:	16 cm insulation 0.024 W/(mK)	→ U = 0.14 W/(m²K)
Basement:	7cm insulation 0.024 W/(mK)	→ U = 0.24 W/(m²K)



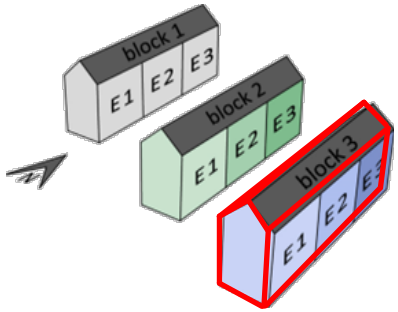
Engineering system retrofit

Heating:	district heating, compact radiators/floor heating
DHW:	central/decentral DHW heat exchanger stations (per entrance/per apartment)
Ventilation:	exhaust air system, window frame fan unit with heat recovery

Retrofit layouts: Block 3 „Passive House“

Structural retrofit

Facade:	8 cm vacuum 0.008 W/(mK)	→ U = 0.11 W/(m²K)
Window:	triple glaze	→ U = 0,80 W/(m²K)
Top floor:	16 cm insulation 0.0024 W/(mK)	→ U = 0,14 W/(m²K)
Basement:	7 cm insulation 0.024 W/(mK)	→ U = 0,24 W/(m²K)



Engineering system retrofit

Heating:	Heatpumps, CO_2-probe head, floor heating, ceiling heating
DHW:	Peripheral DHW heat exchanger stations (per apartment)
Ventilation:	Ventilation system wit heat recovery

Impressions of the construction site I/V

Inlet air element - window

Outside solar protection with light control system

Impressions of the construction site III/V

Vakuumdämmung
λ=0,006 W/(mK)

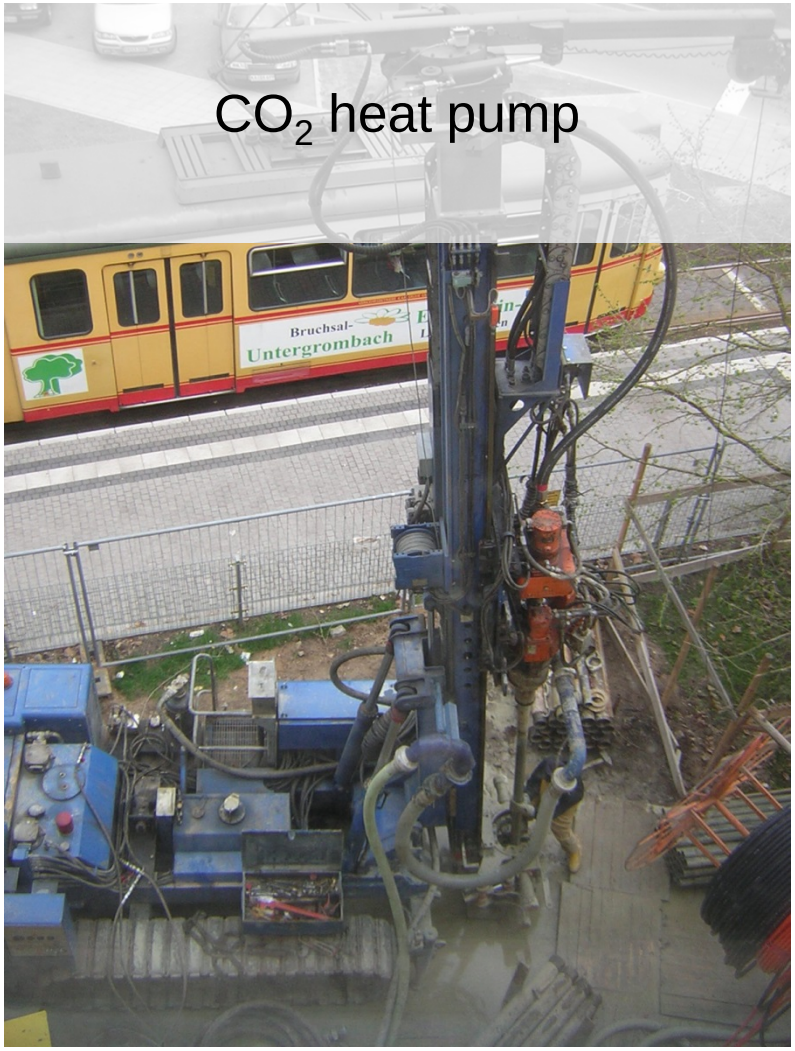
Impressions of the construction site IV/V

Heating system

Floor heating

Impressions of the construction site V/V

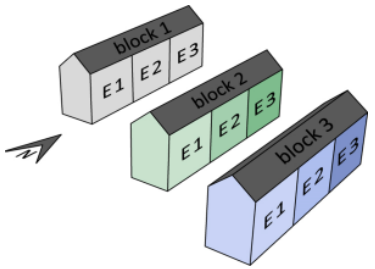
Decentralised controlled ventilation system

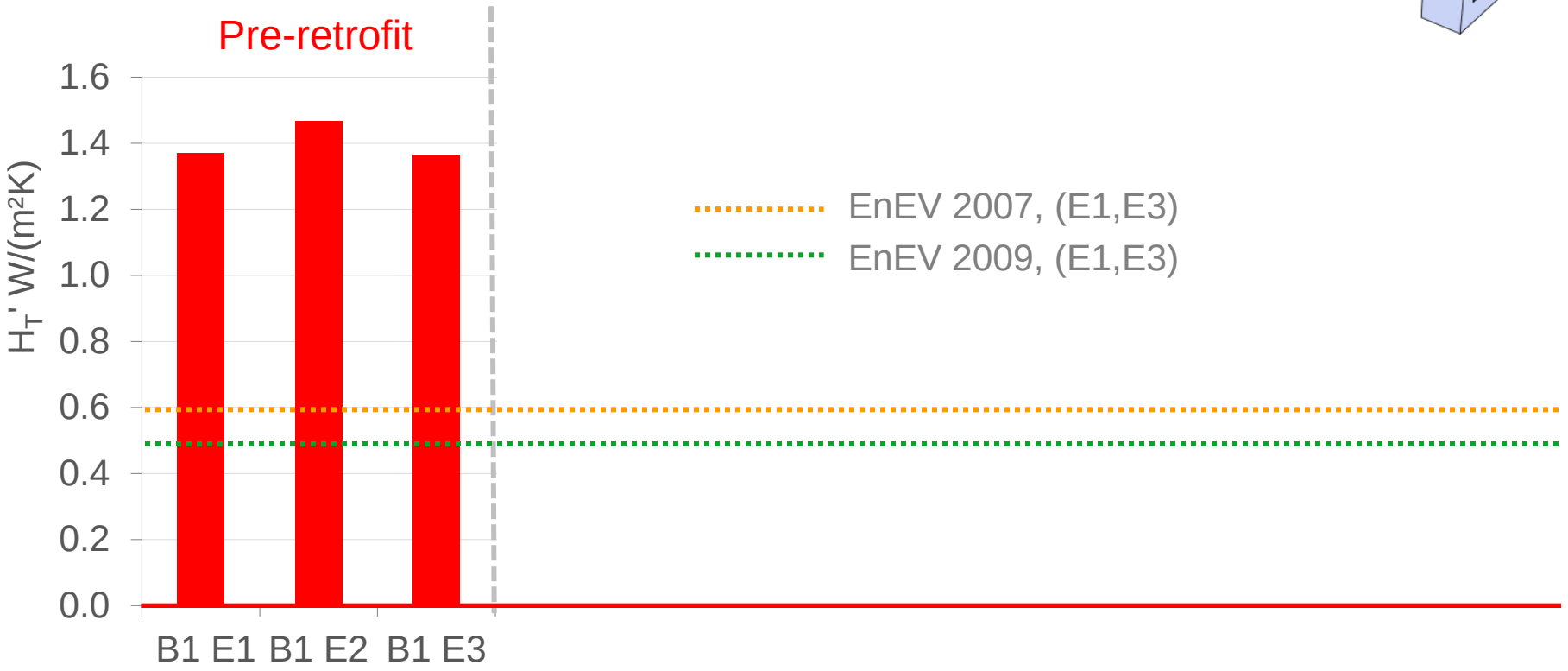


CO_2 heat pump

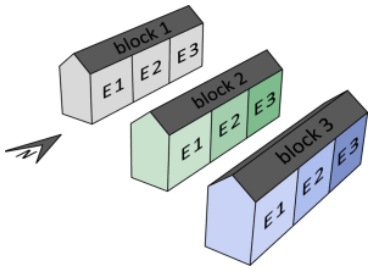
Buildings before and after retrofit

Specific heat transmission $H`_T$

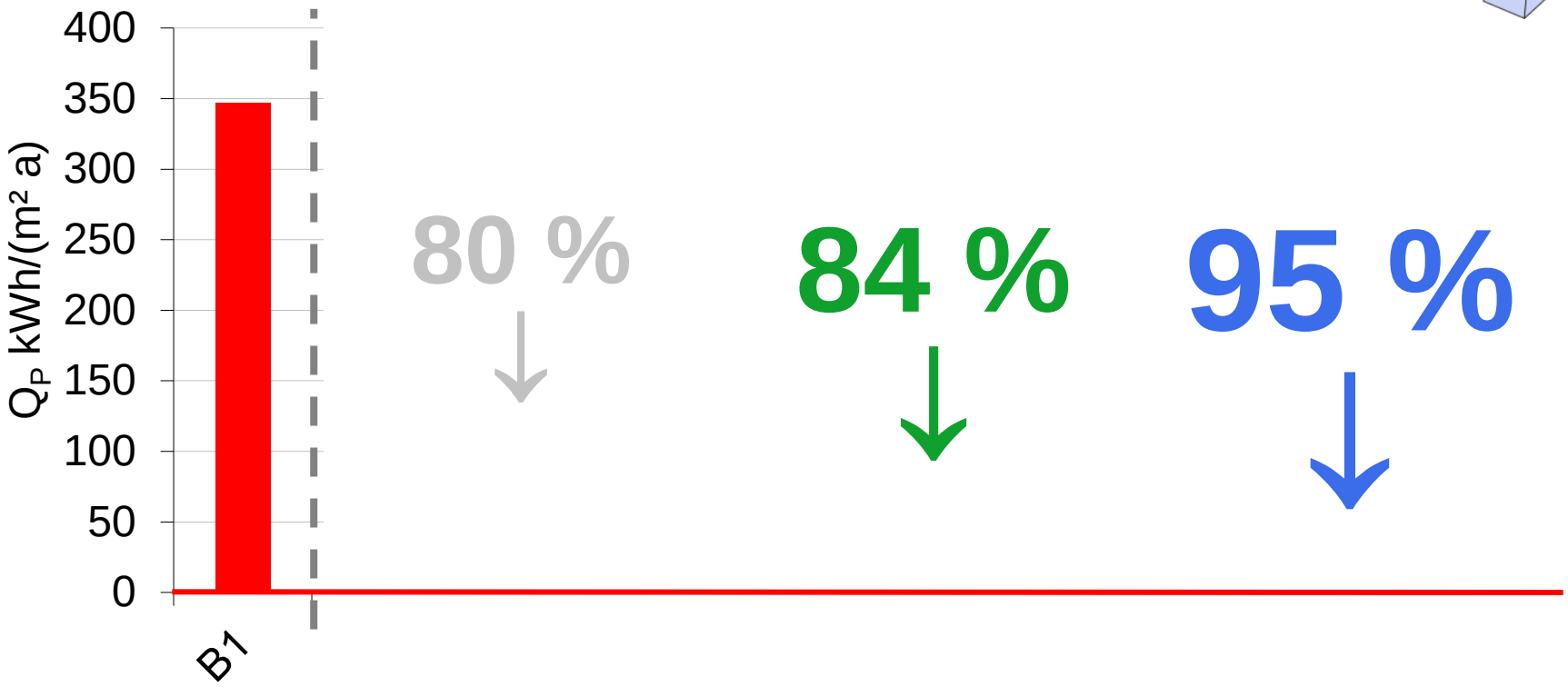




Primary energy demand Q_P



Pre-retrofit



The monitoring system

Weather station:

Ambient temperature / rel. humidity / global radiation / wind direction and speed, luminosity

X = Temperature sensor under stucco

X = Temperature sensor under insulation

The monitoring system

Each apartment:

DHW

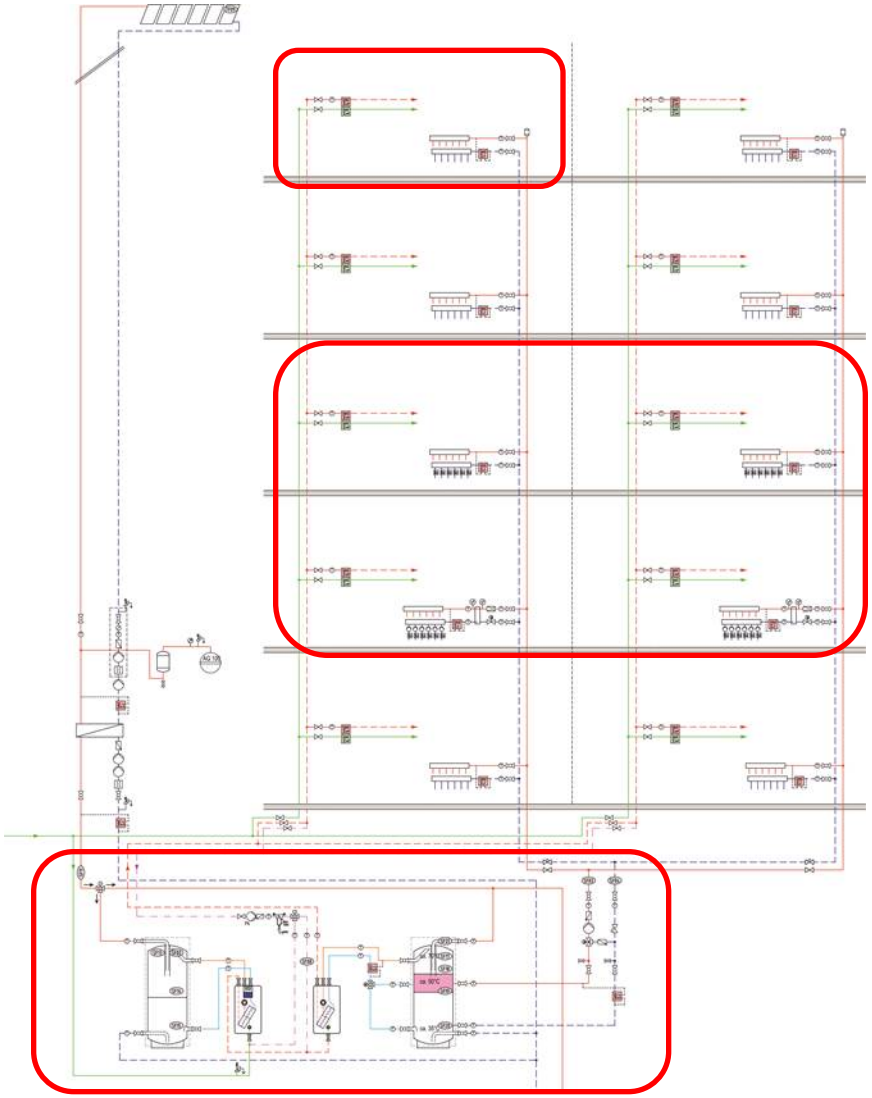
- Flow temp.
- Return temp.
- Volume flow

Heating

- Flow temp.
- Return temp.
- Volume flow

Ventilation

- Flow temp.
- Return temp.



Each room:

- Flow temp.
- Return temp.
- Volume flow

Basement:

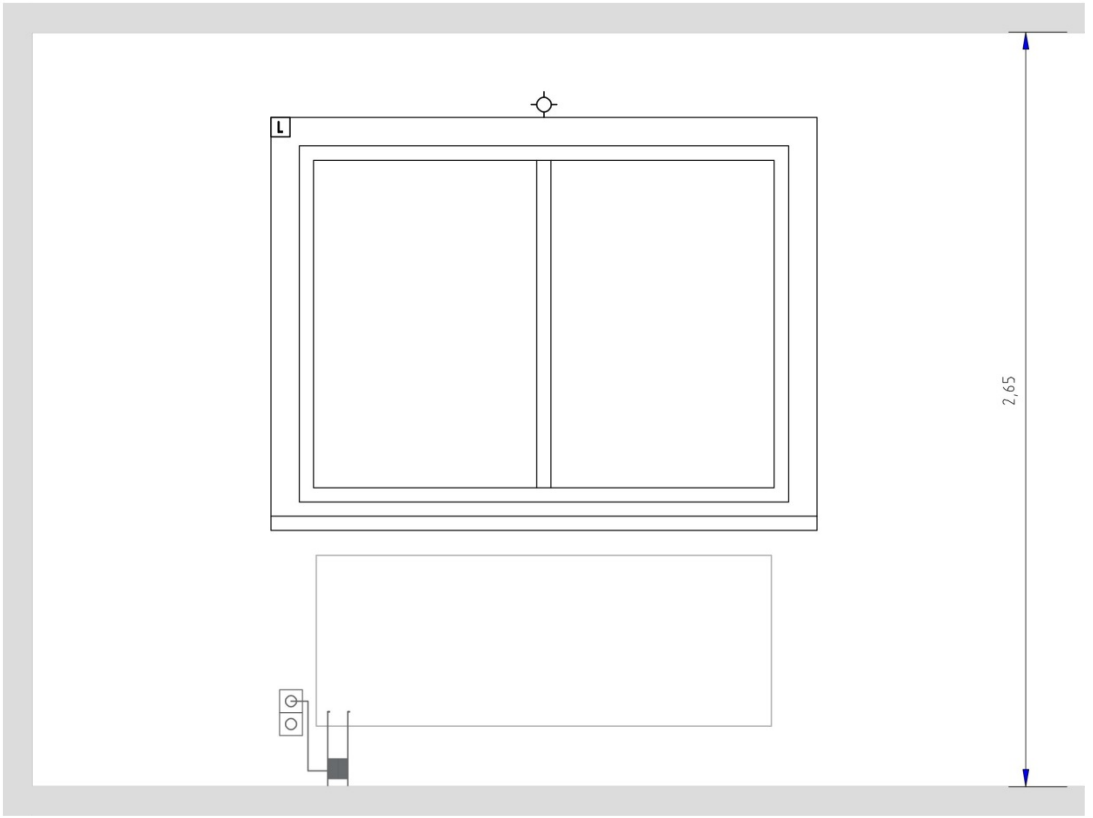
- Electricity
- Heating energy
- Storage temperature
- Flow/Return temp.

The monitoring system

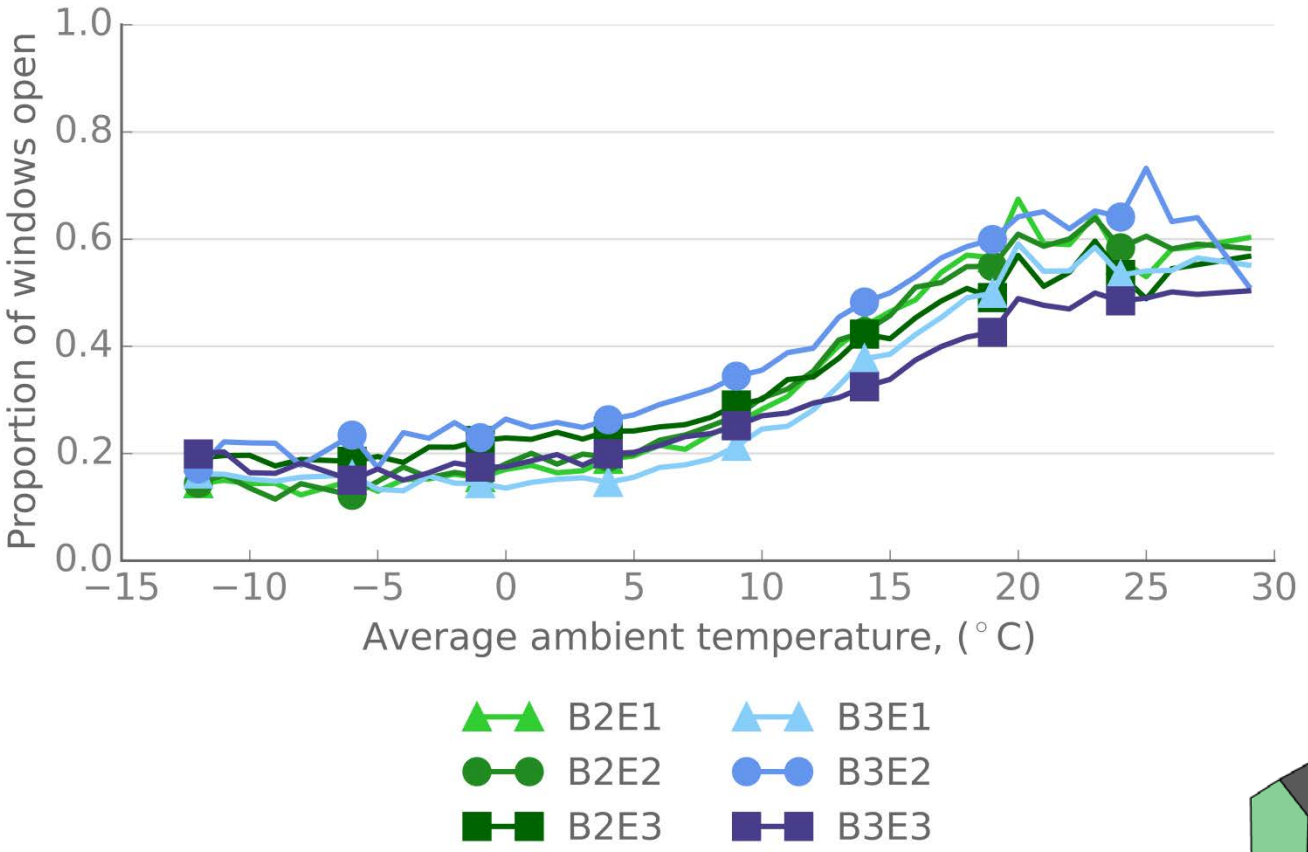
Wall 2 Wall1

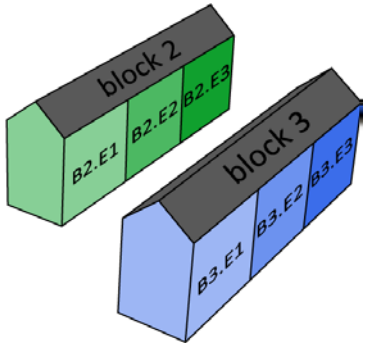
Meas. Module **MM**:

- Room temperature
- Rel. humidity
- Volatile organic compounds
- Carbon dioxid
- Visible light/Infra-red and Luminosity
- Windows opening



Evaluation of the measured data: Tenants behavior





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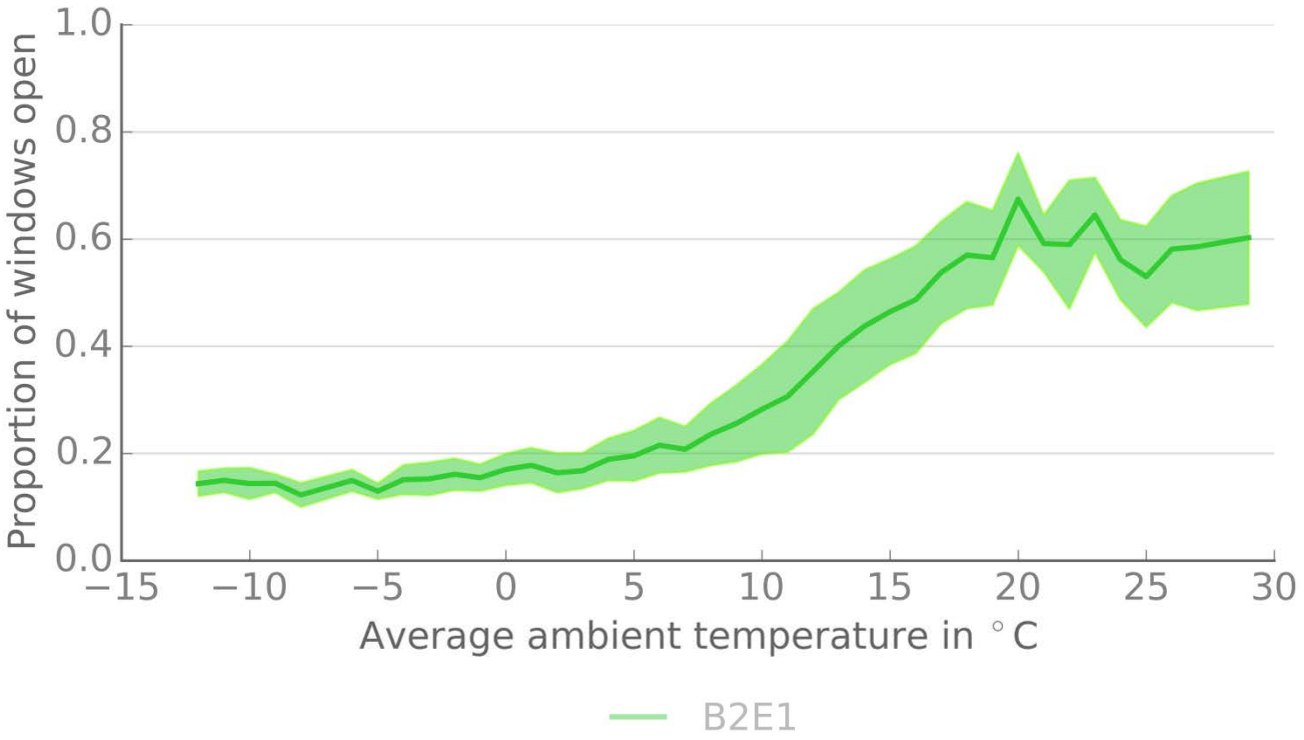

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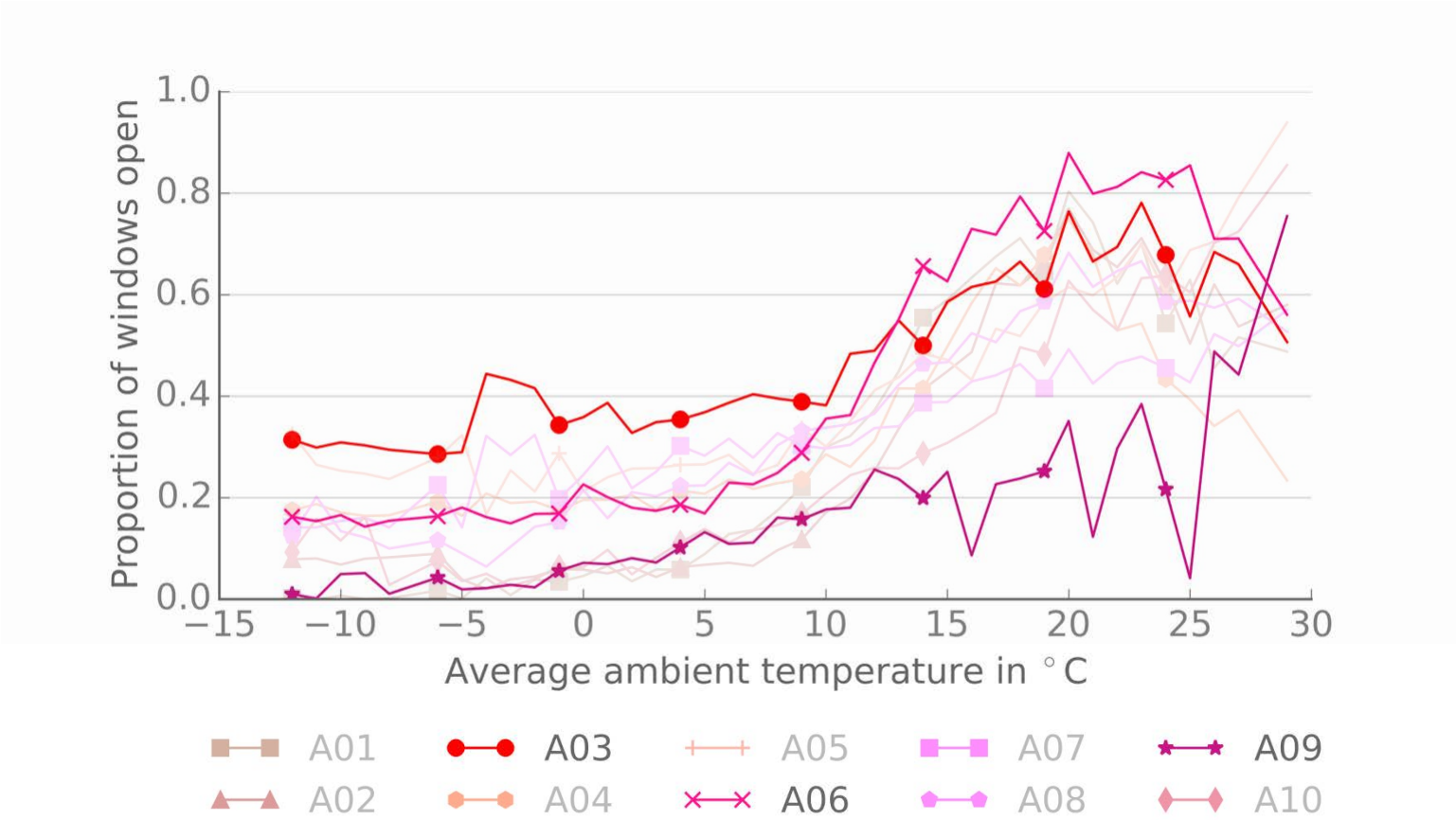

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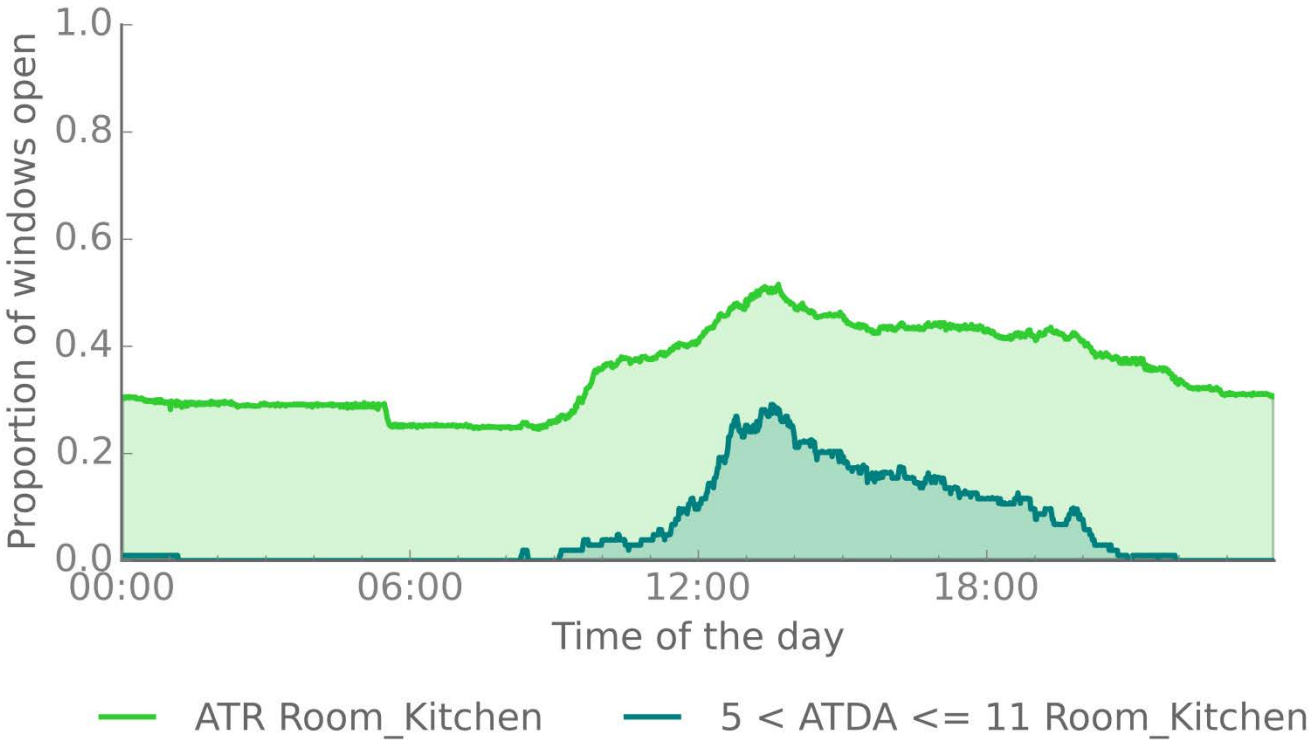

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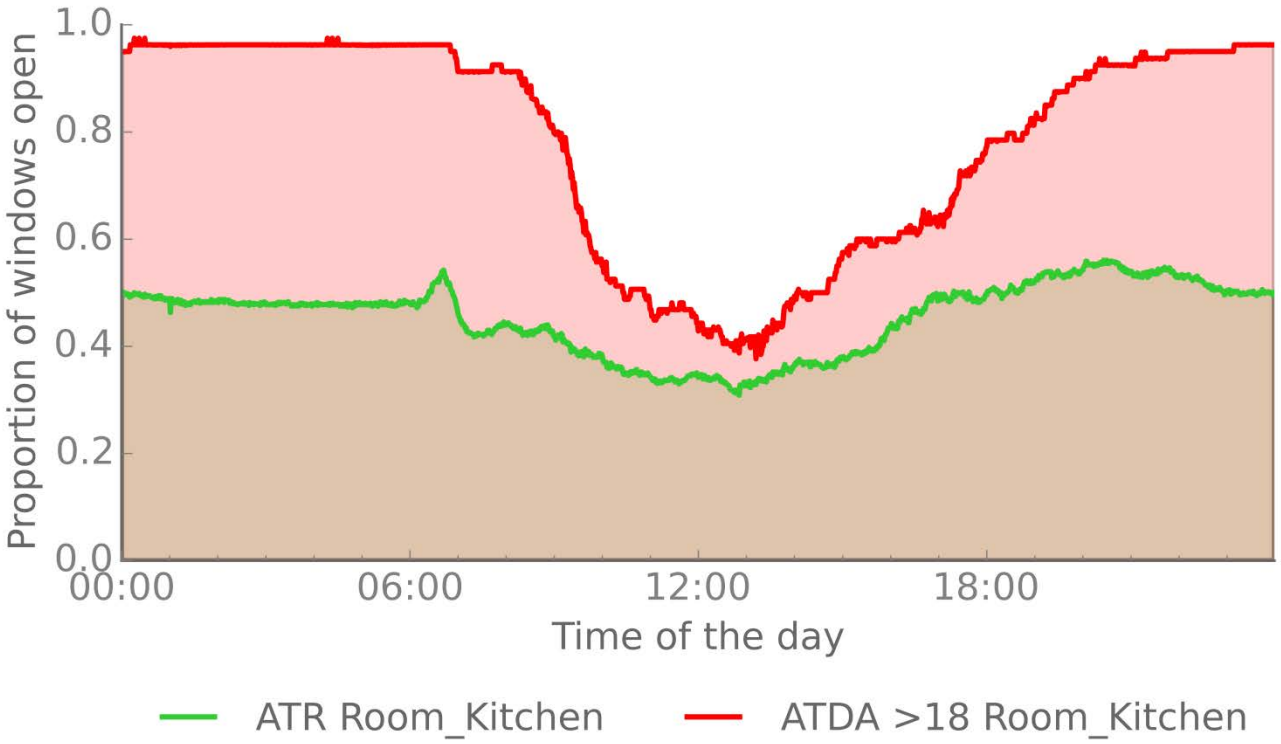

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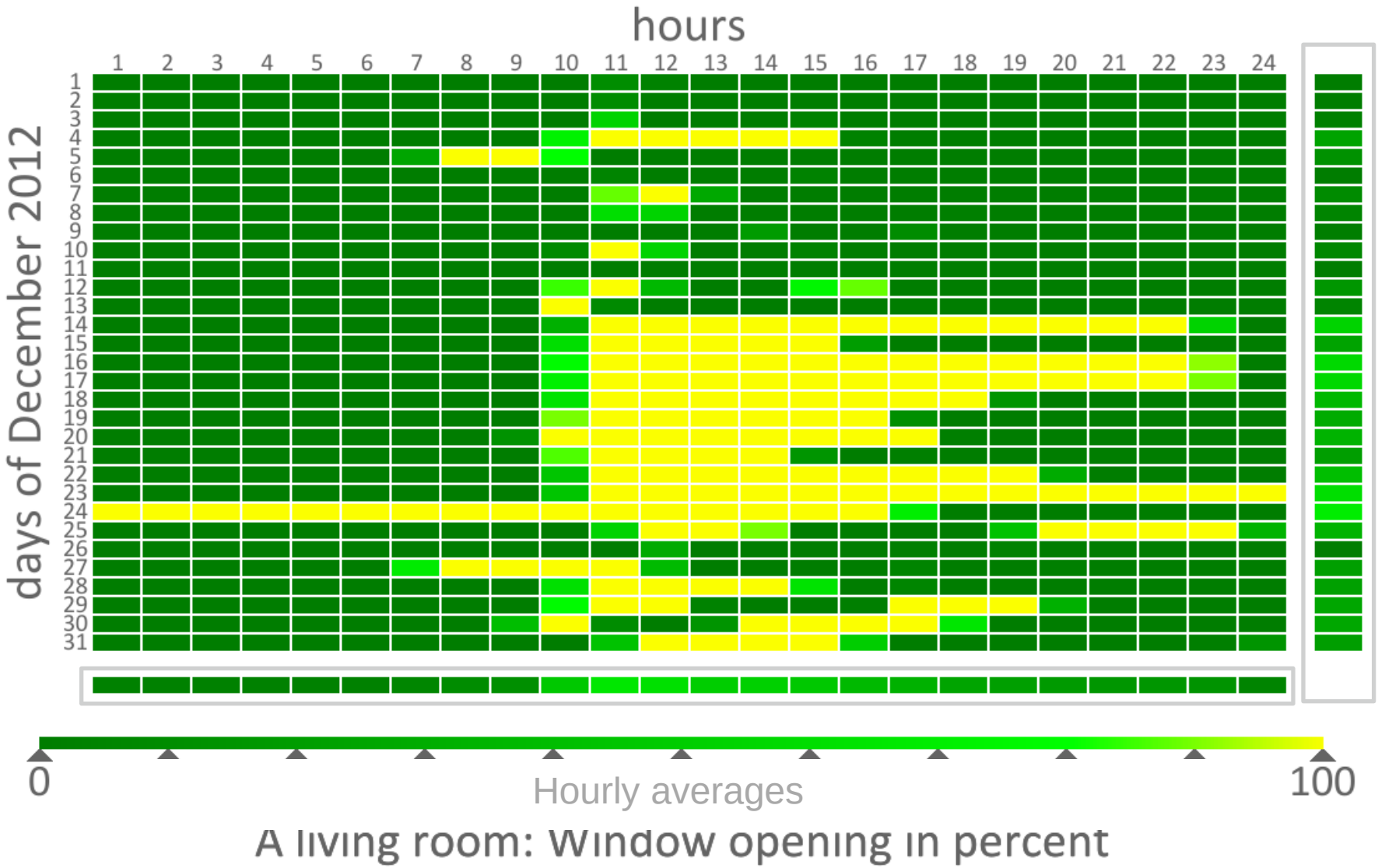

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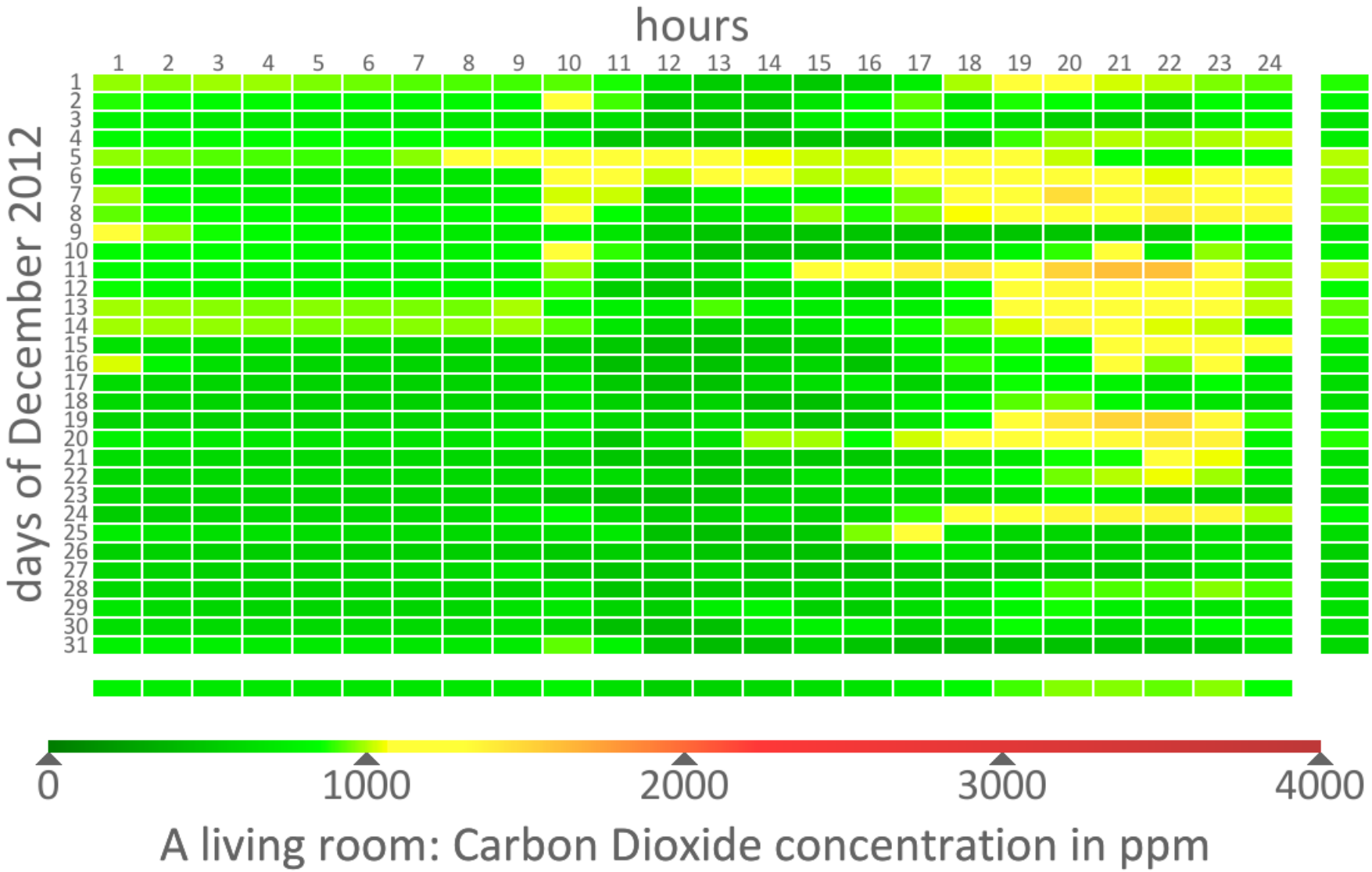

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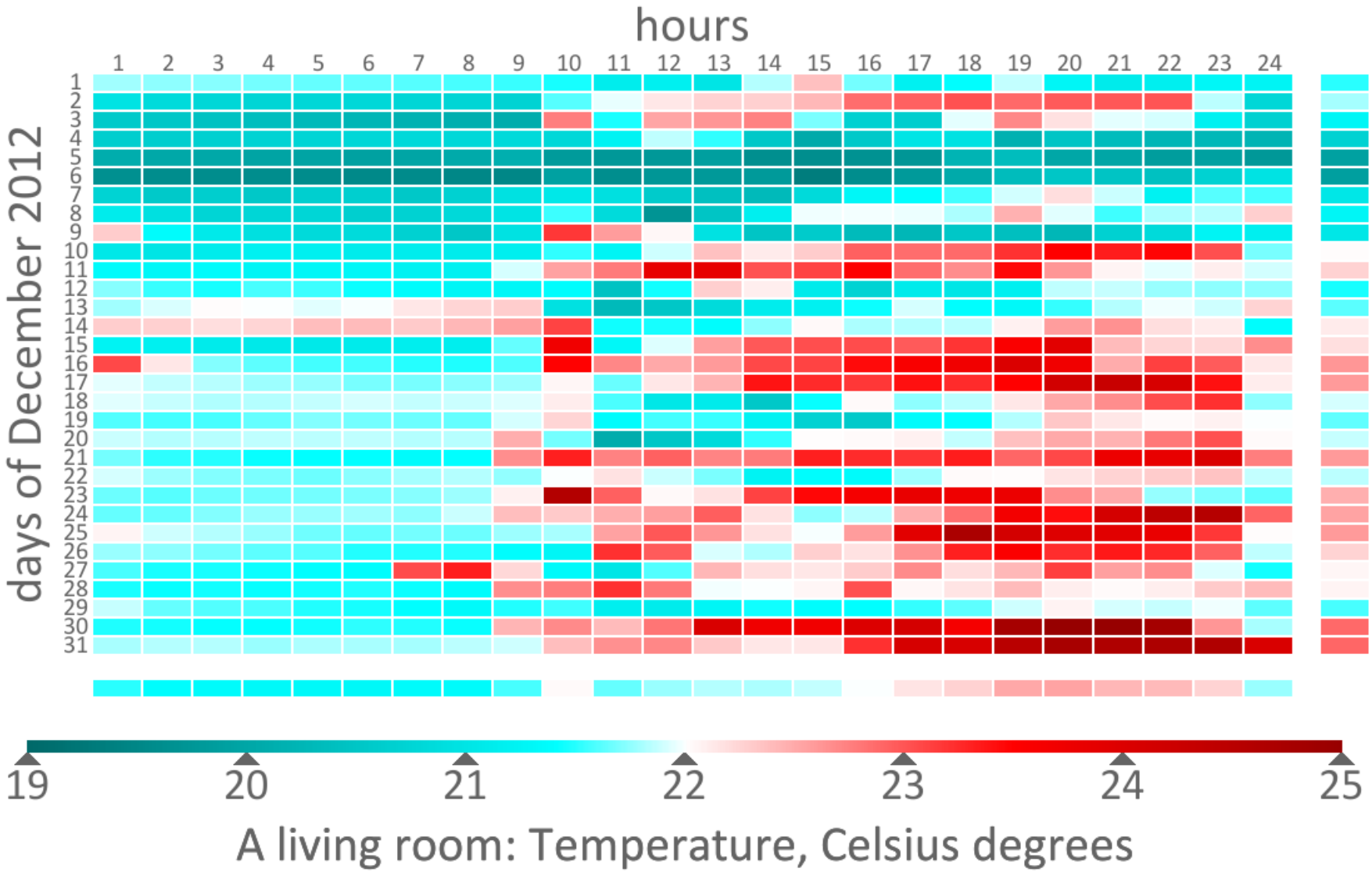
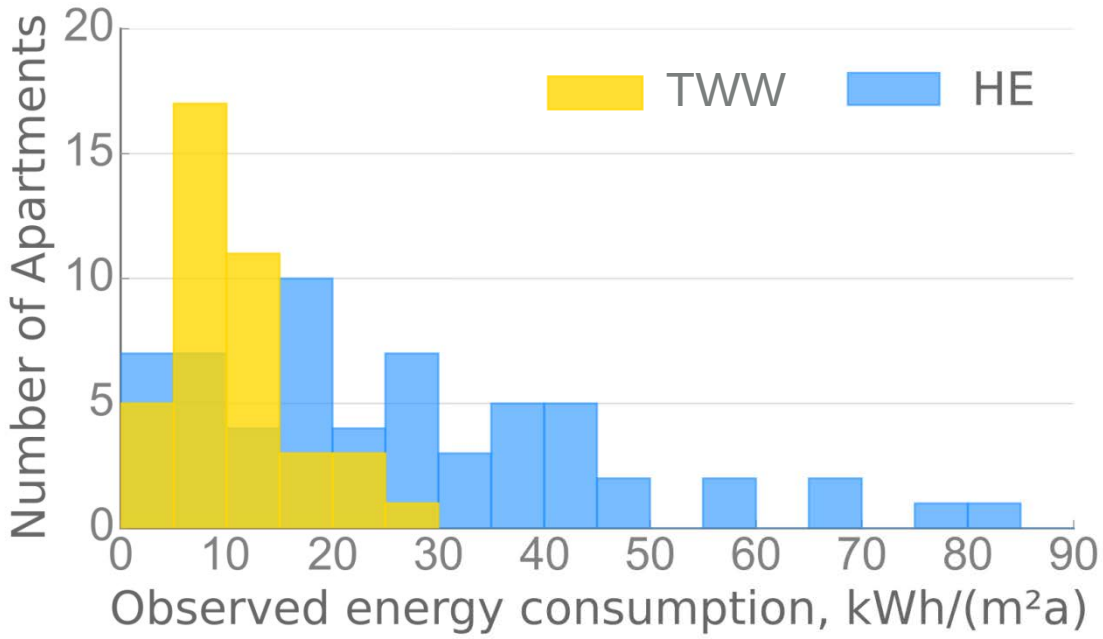
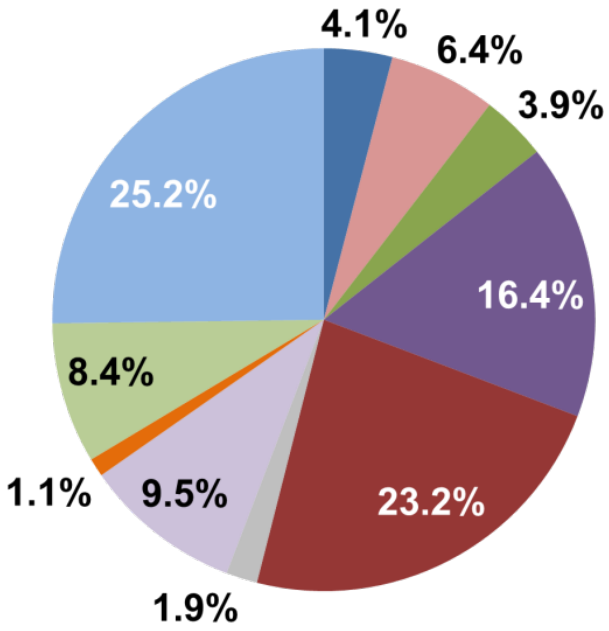
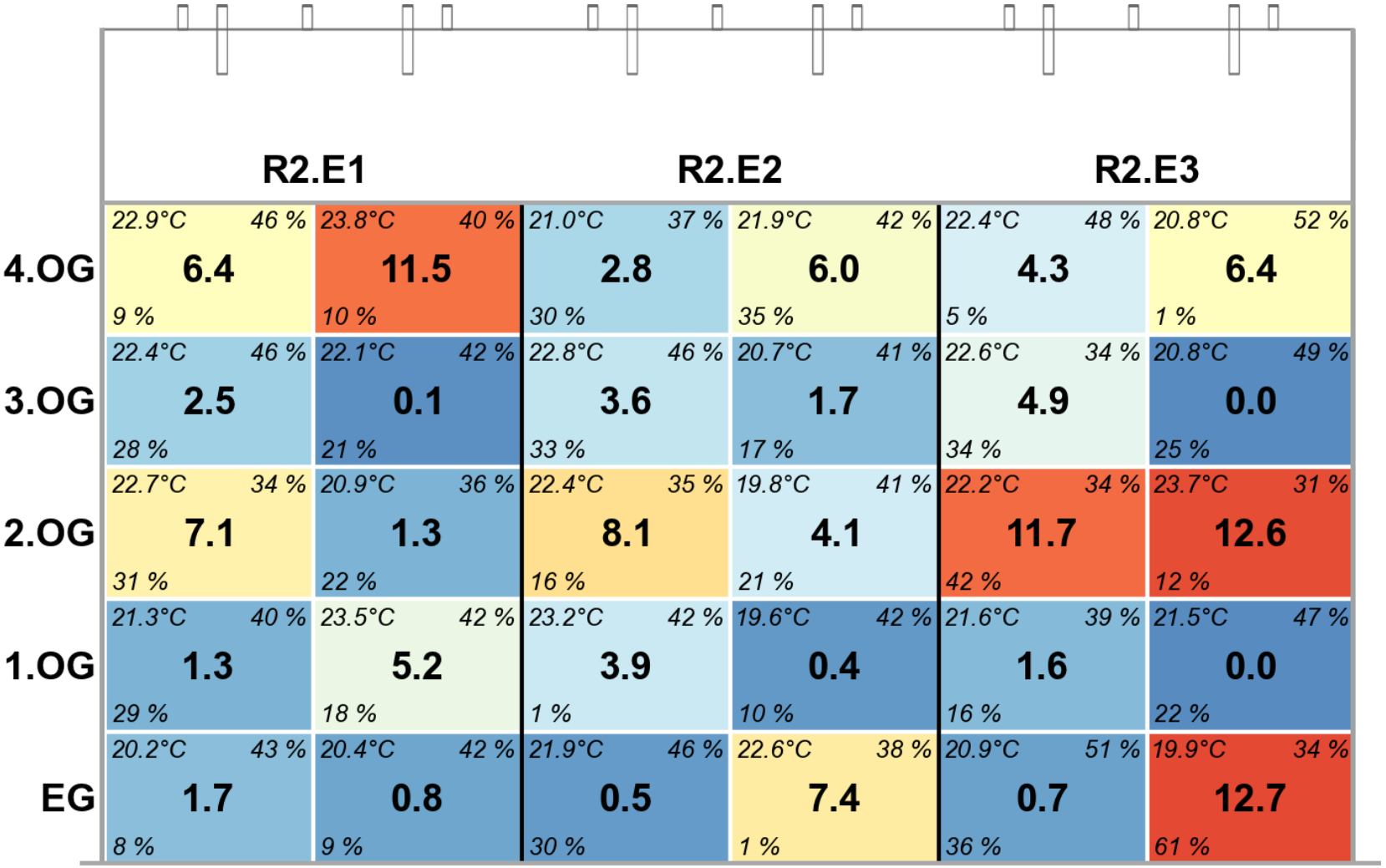


Heizenergieverbrauch

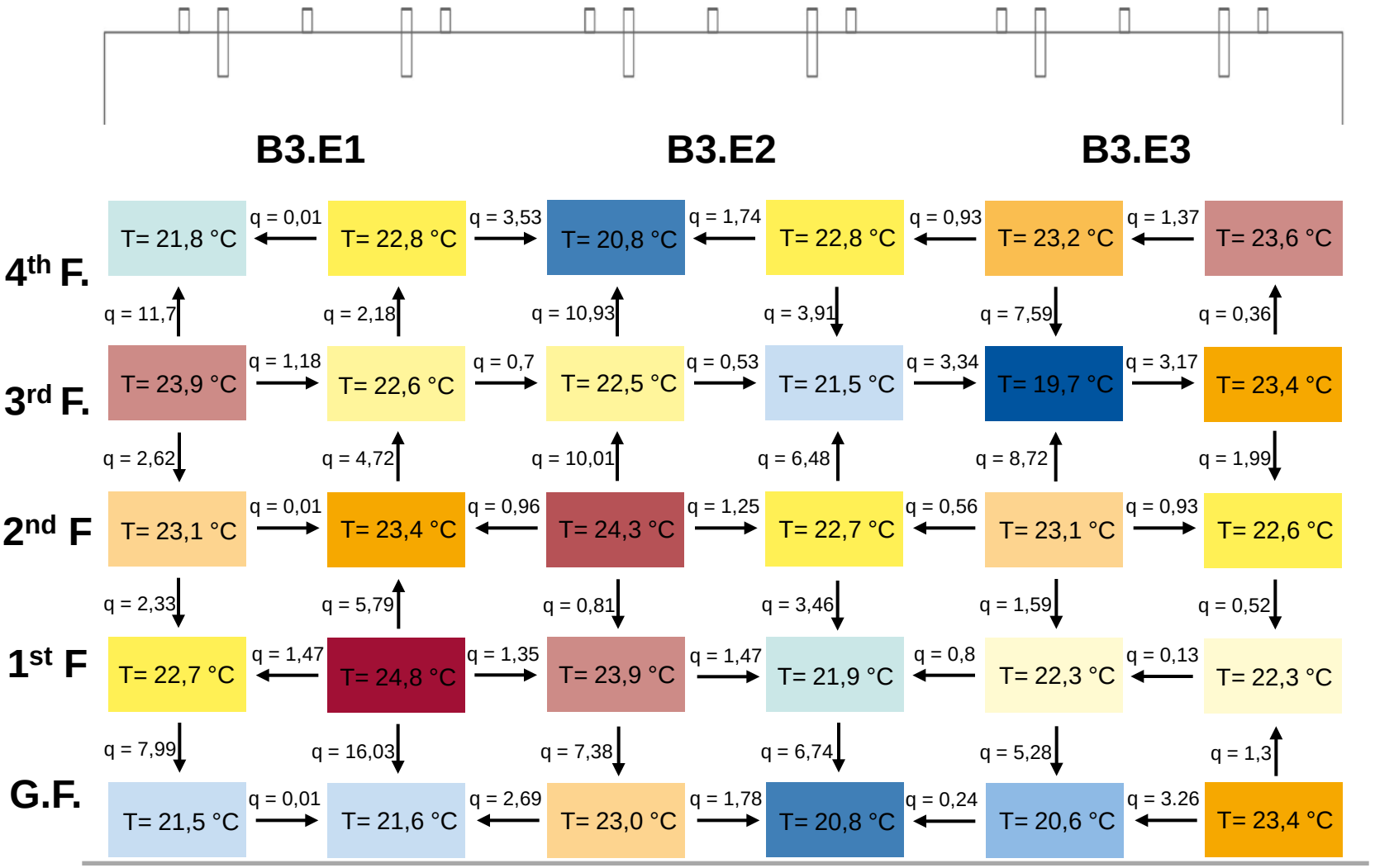




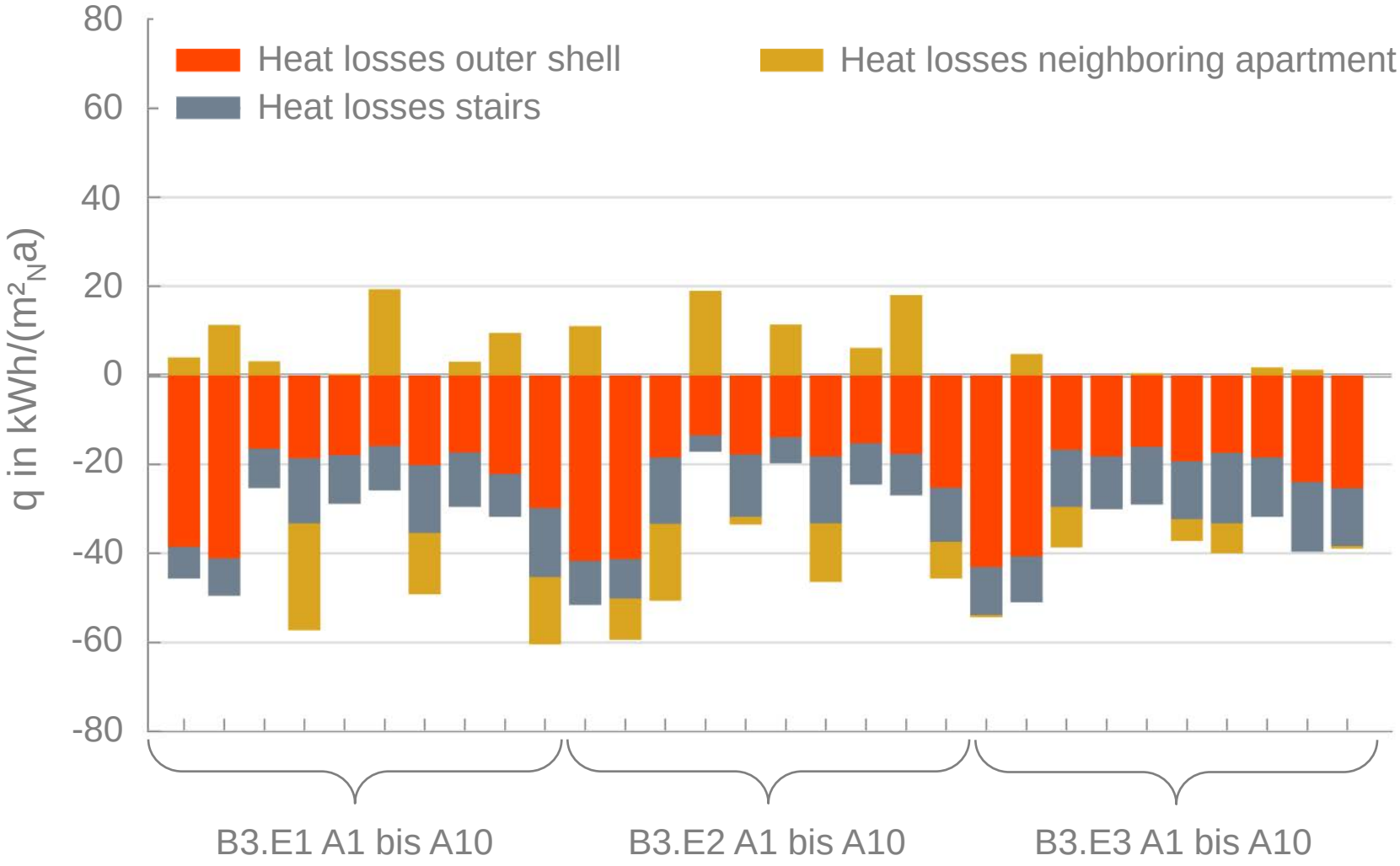
Evaluation of the measured data: A winter month



Heat displacement (q in kWh/m² $_{WF}$) in block 3 during one heating period

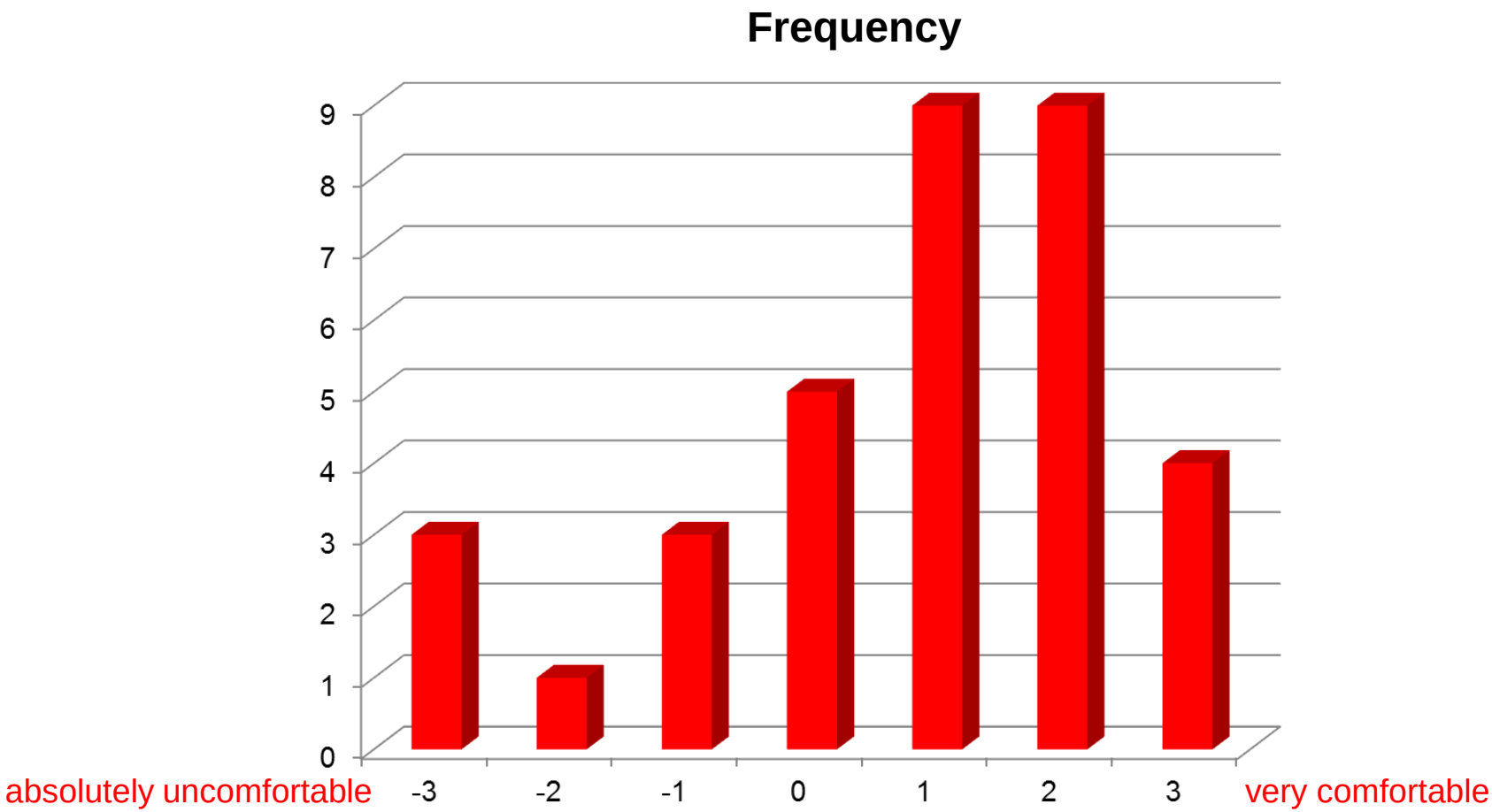


Comparison of the heat losses about the outer shell, to the stairwell and the neighboring apartment for block 3



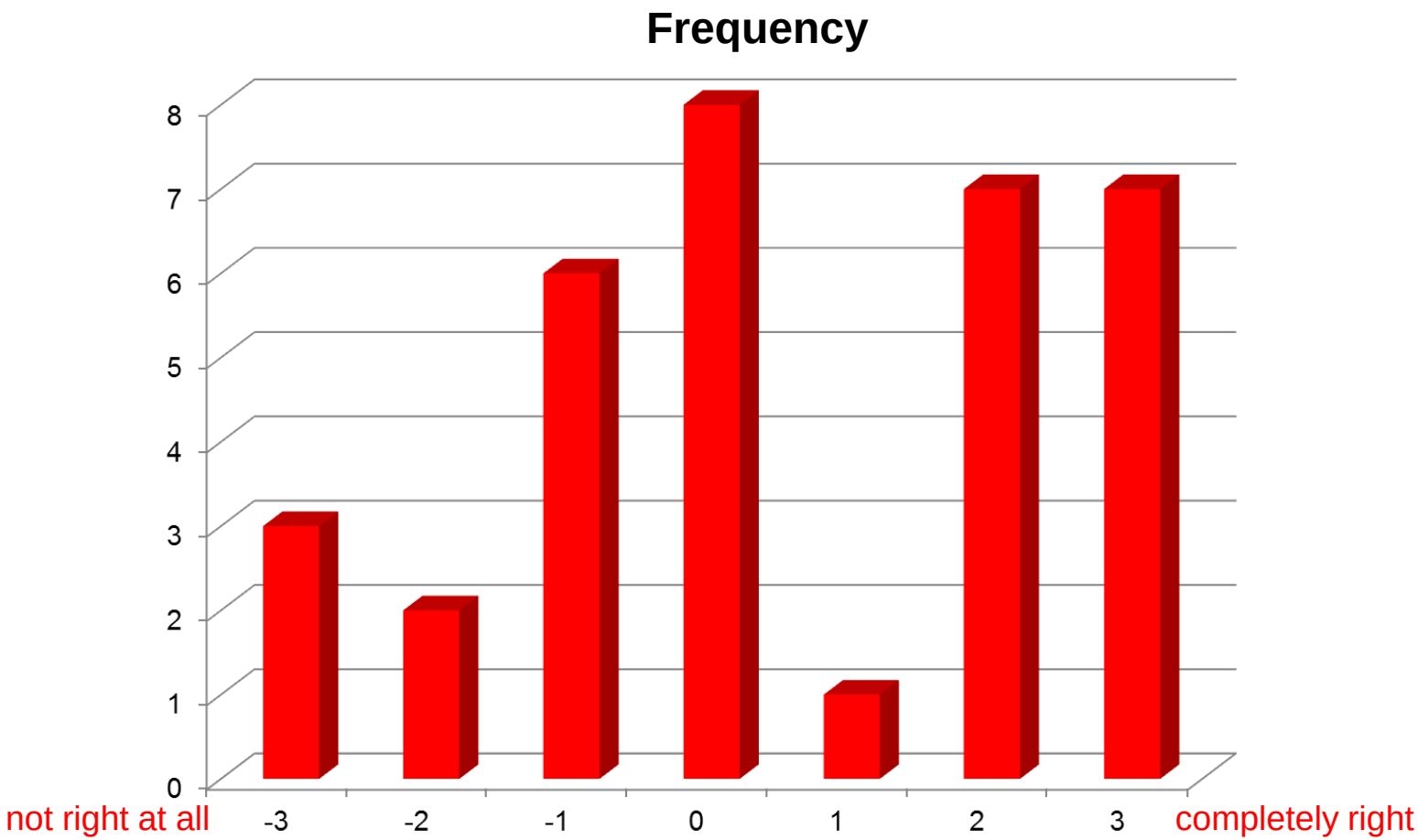
Questionnaire – single results

- On a scale from -3 to 3: what is your impression about the apartment



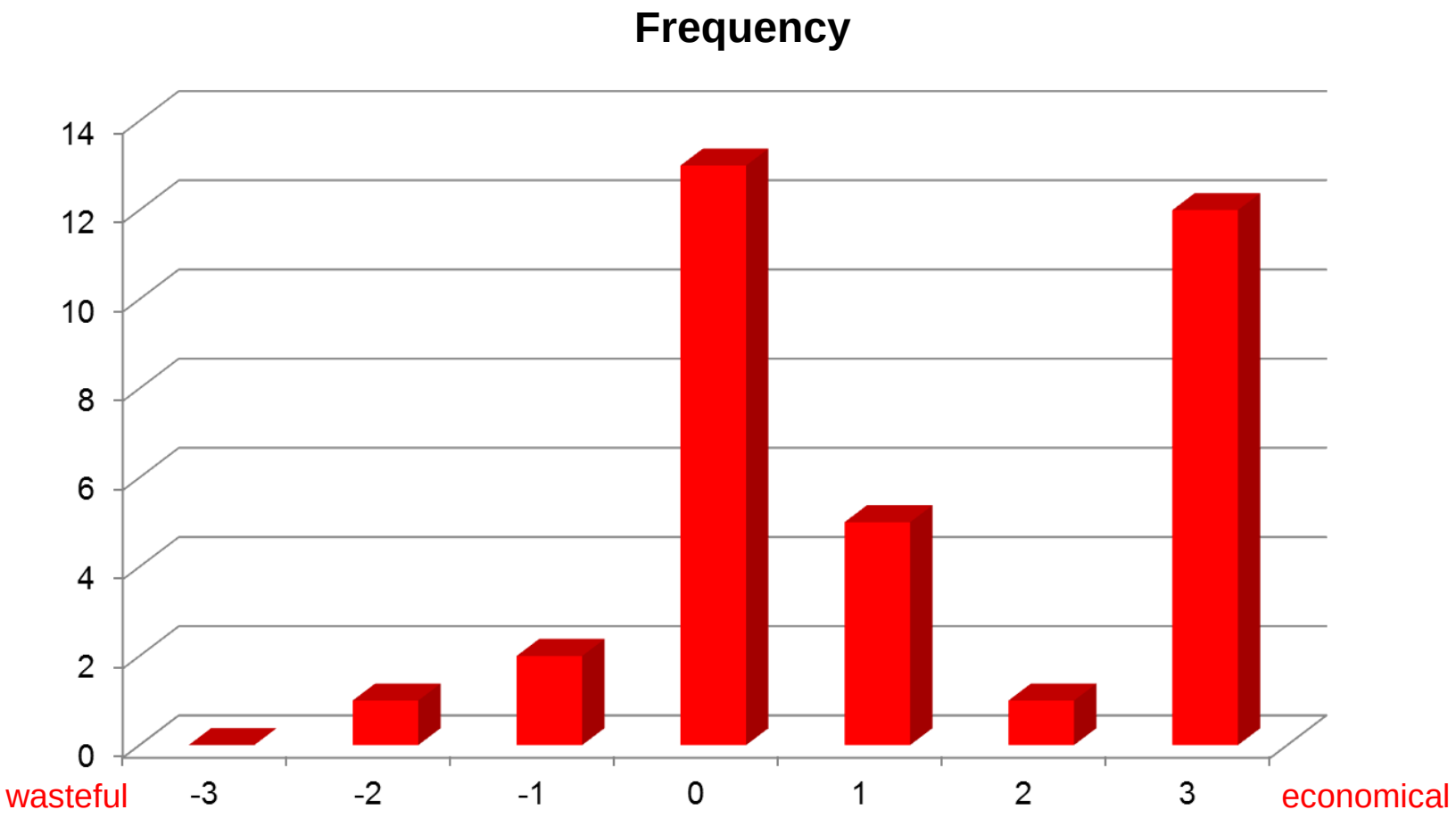
Questionnaire – single results

- Since the refurbishment, the interaction with the system develops more comfortably.

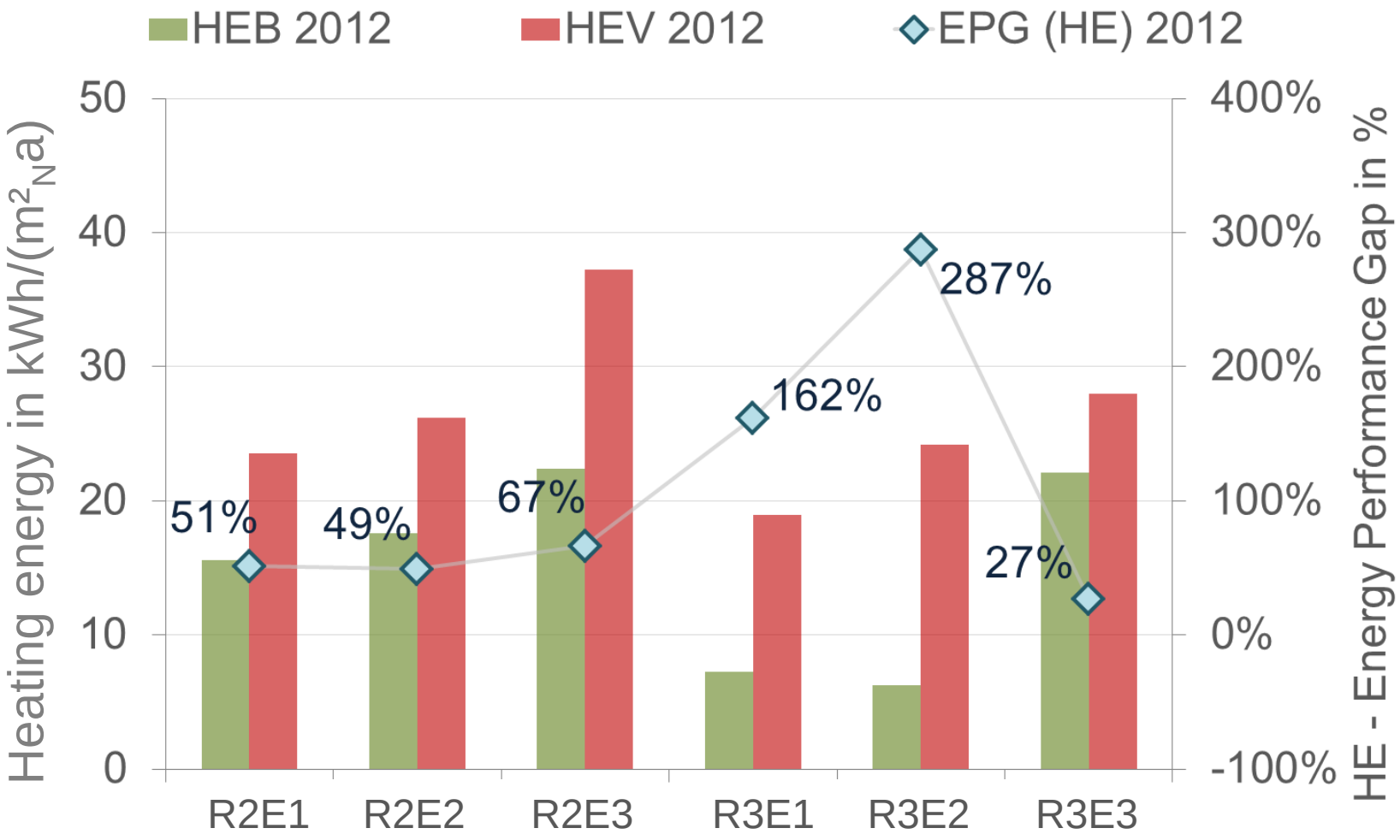


Questionnaire – single results

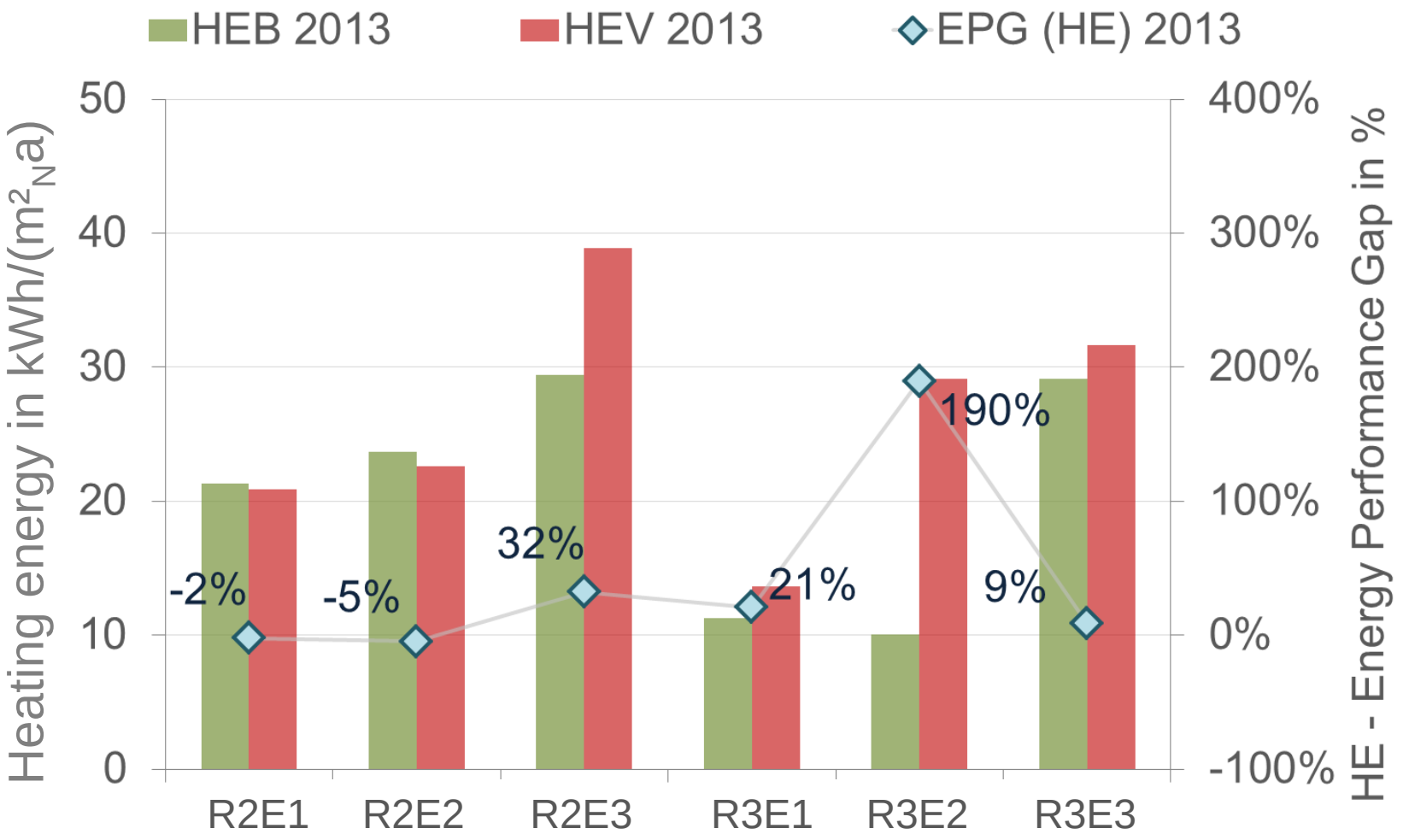
- On a scale of from -3 to 3, how do you estimate yourselves, regarding your energy consumption?



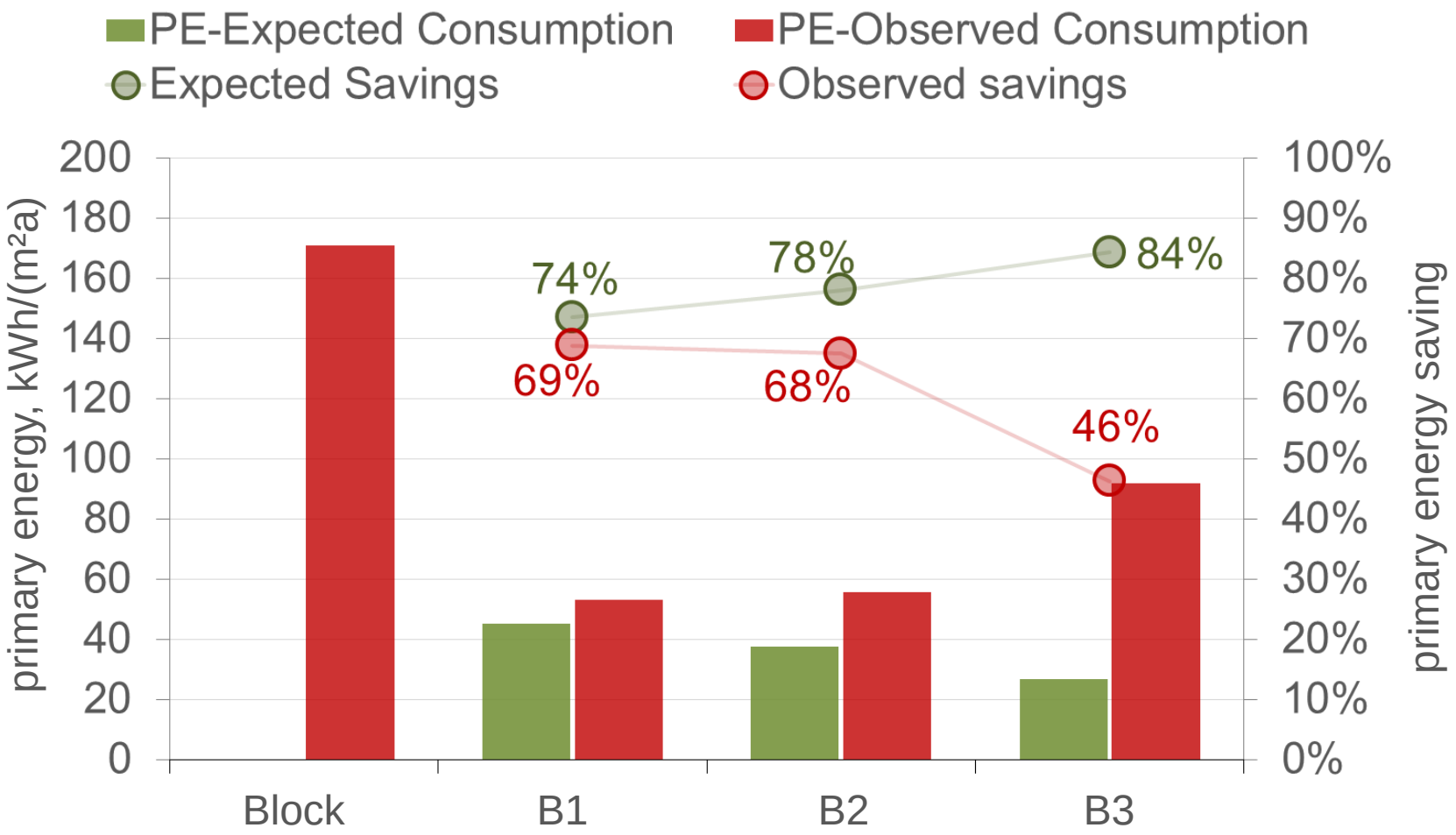
Gegenüberstellung Heizwärmebedarf /-verbrauch 2012



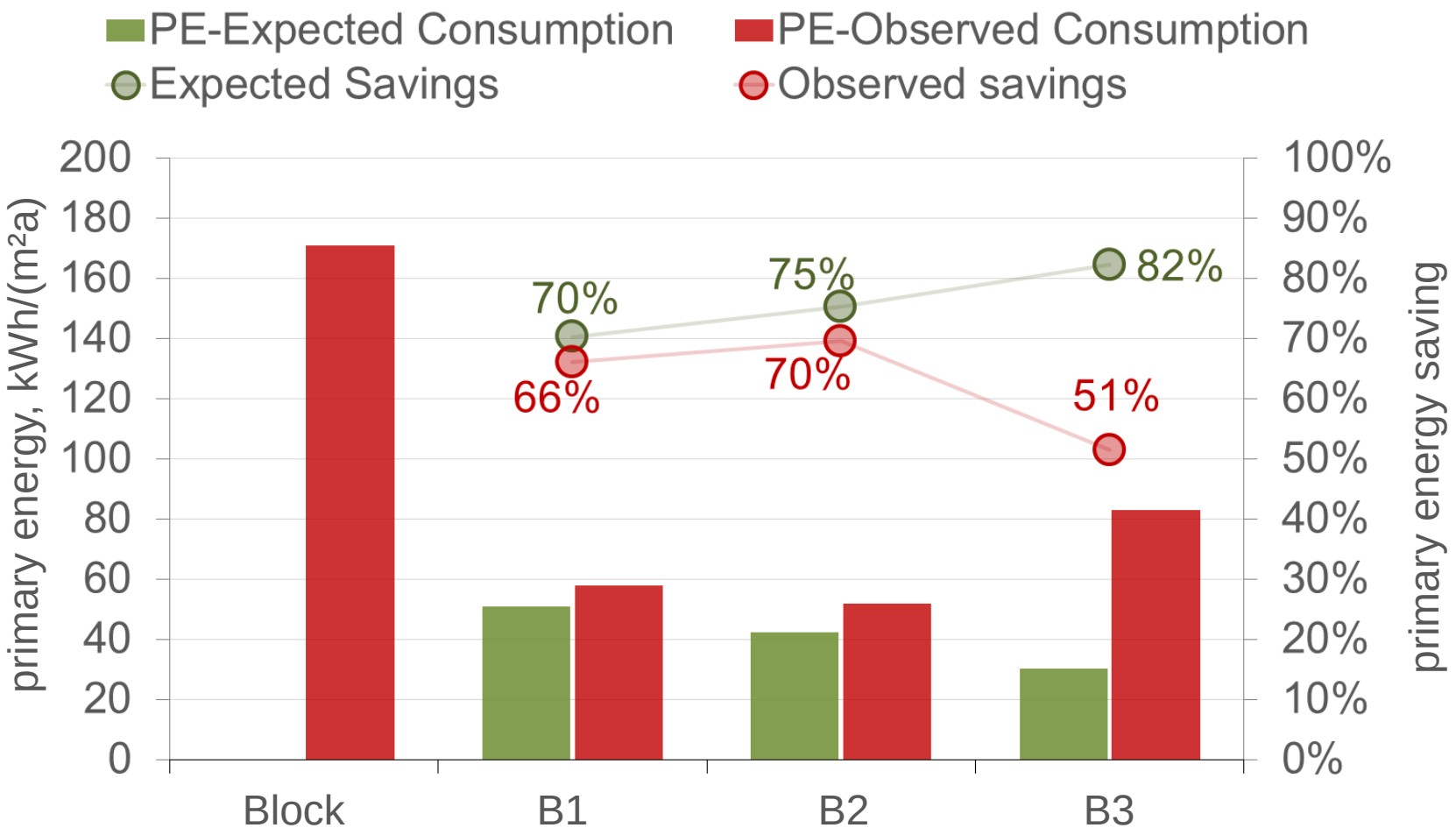
Gegenüberstellung Heizwärmebedarf /-verbrauch 2013



Expected vs. observed primary energy in the year 2012



Expected vs. observed primary energy in the year 2013



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