

HOUSES WITH DECENTRAL COMPACT HEAT PUMPS

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- AEE INTEC
- Siko Energiesysteme
- Pichlerluft
- Vaillant
- Kulmer
- Internorm

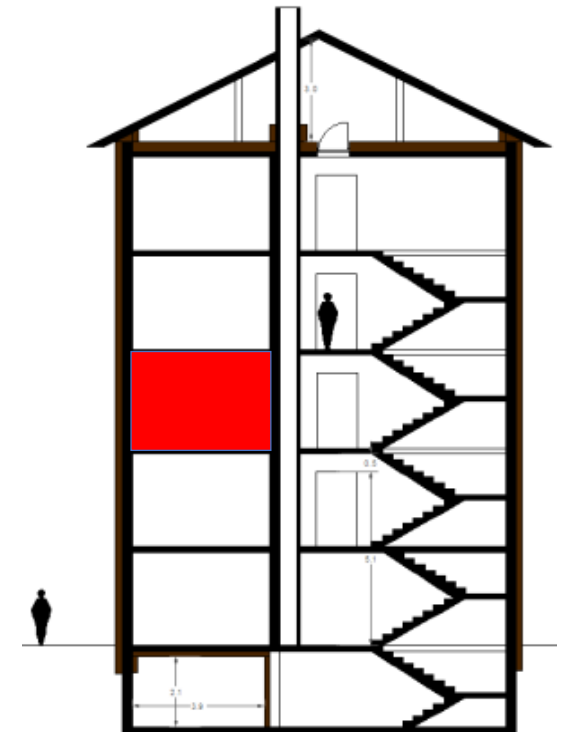
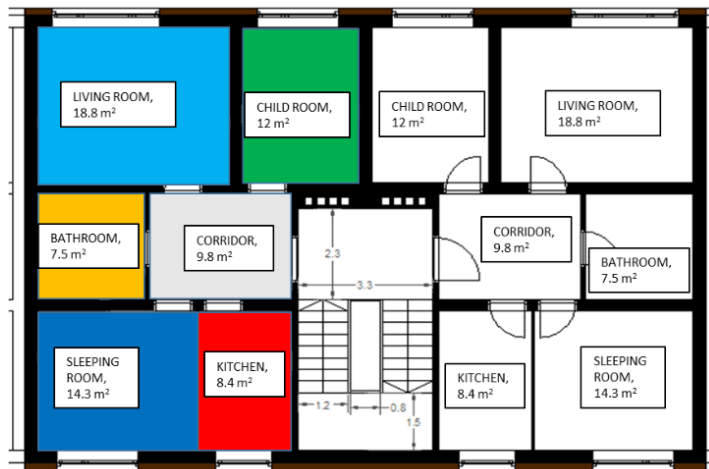
Introduction and Motivation

- **Deep energy renovation** of the buildings represents one of the most relevant steps into a future sustainable energy system
- Central heating and ventilation system is not feasible (technically, economically) in a large number of cases
- **Compact decentral heat pumps** in combination with Mechanical Ventilation with Heat Recovery (**MVHR**) represent one of the possible solutions for renovated flats in Multi Family Houses (MFHs)
- Such a system can be **integrated** into a prefabricated timber frame **façade** and enables a non-disruptive renovation
- Within the framework of the Austrian FFG project *SaLüH!*, such a **compact and cost-effective heating and ventilation concept** was developed and investigated



Reference Building and Model

- Typical multi-story building located in Innsbruck (annual average ambient temperature of 9.1 °C), renovated to **EnerPHit standard (25 kWh/(m² a))**
- The reference flat (area of **70.9 m²**) is the flat of the first floor oriented to the Northeast side (highlighted in red)
- **model** (Matlab/Simulink, Carnot Blockset) with **six thermal zones** (one for each room), flats (below, above and adjacent), basement, staircase and ambient are BCs

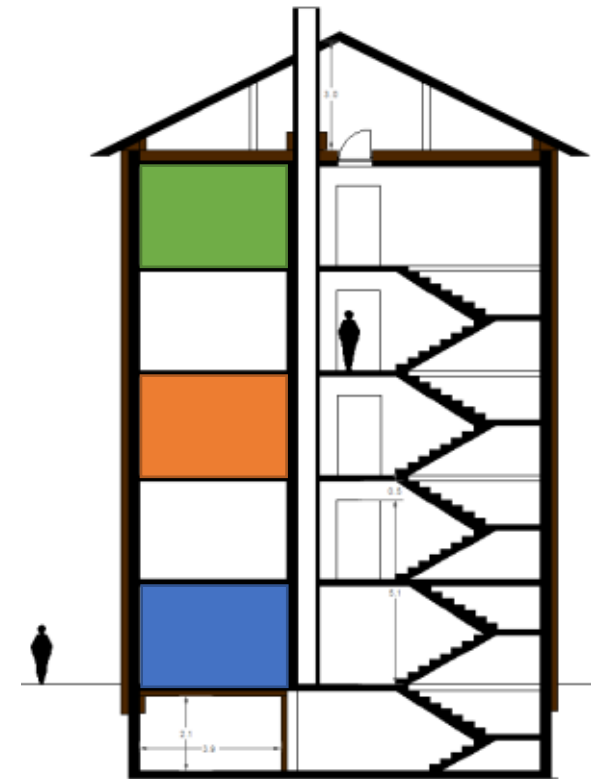


Position of the Flat and Heating Demand

EnerPHit: 25 kWh/(m² a)



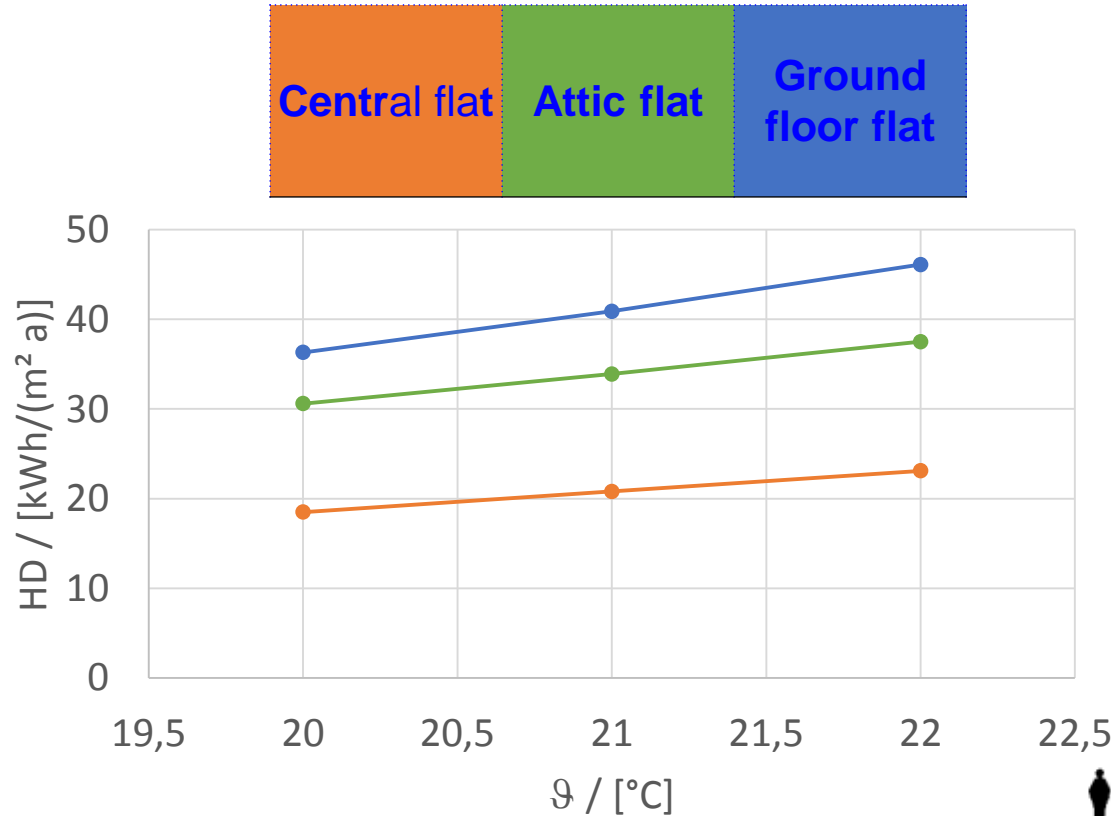
		Central flat	Attic flat	Ground floor flat
		20 °C		
HD	kWh/(m ² a)	18.5	30.6	36.3
HL	W/m ²	16.2	20.4	18.9
		21 °C		
HD	kWh/(m ² a)	20.8	33.9	40.9
HL	W/m ²	17.3	21.6	19.9
		22 °C		
HD	kWh/(m ² a)	23.1	37.5	46.1
HL	W/m ²	18.5	22.8	20.9



PHPP, 60 m² treated area
(traffic area excluded),
adiabatic, staircase heated

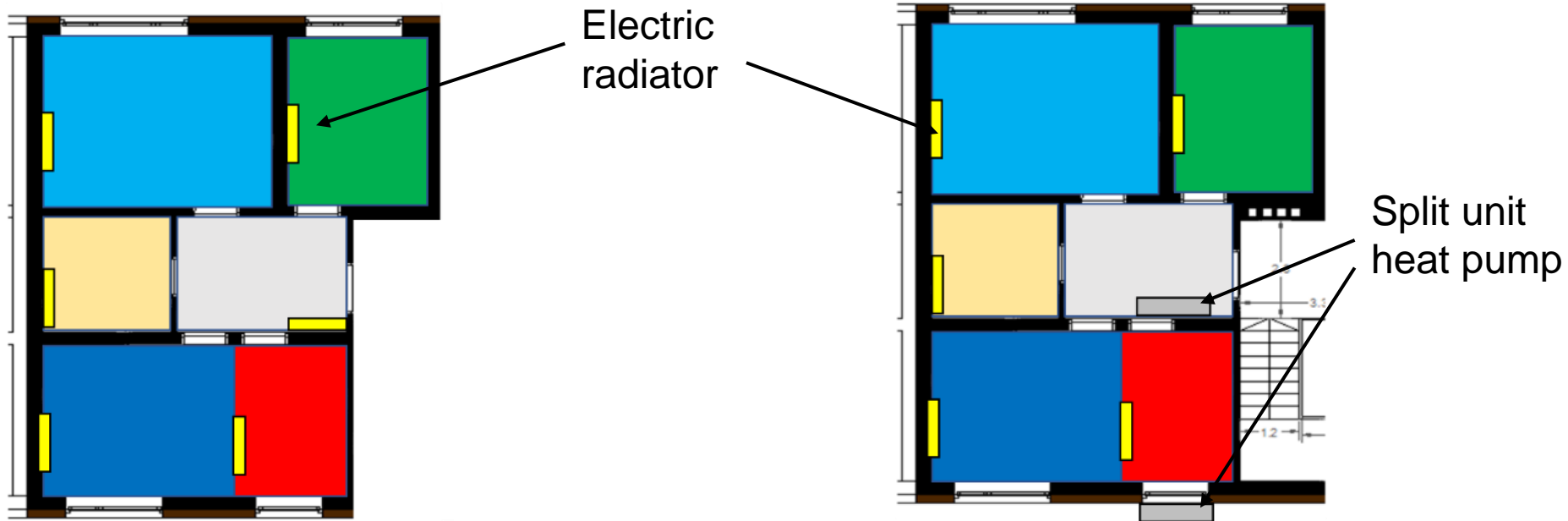
Position of the Flat and Heating Demand

EnerPHit: 25 kWh/(m² a)



Influence of position and set point

Decentral heating concepts, electric radiator



Electric radiator room-wise

- Low investment costs but high operating costs
- room-wise control of temperature
- Independence of ventilation and heating systems

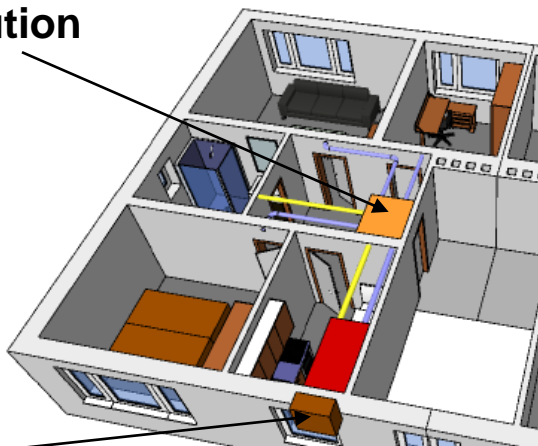
Split unit with recirculation of air in corridor

- Split unit heat pump heats the air of the CO and, indirectly, the others rooms
- Electric post-heaters are placed in all the rooms, except the CO
- Variant: Multi-Split

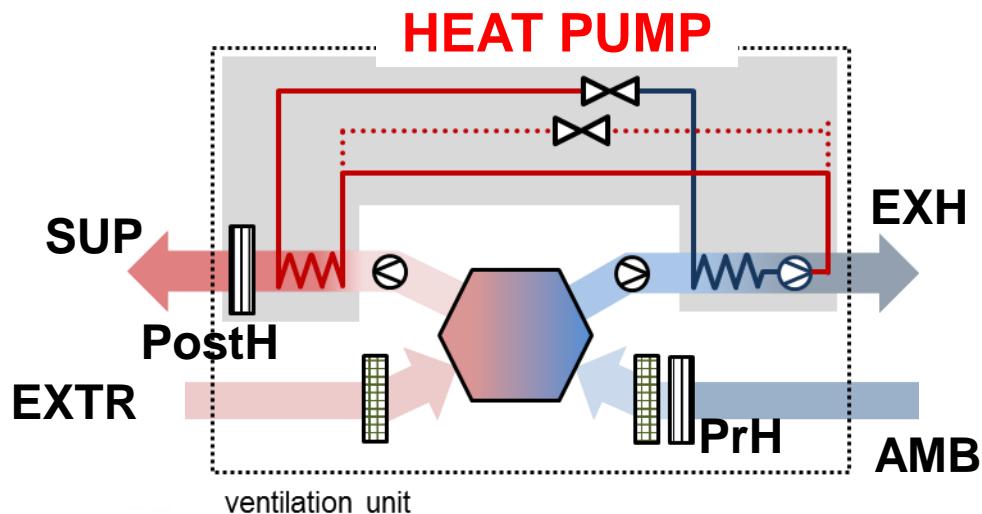
Decentral heating concepts, supply-air HP

- **Supply air/exhaust air heat pump** system in combination with MVHR
- Ducts of the ventilation system are used to distribute space heating power
- Air is supplied to the SL, CH and LI and is extracted from BA and KI
- Additional bath room radiator for reasons of comfort

Air distribution system

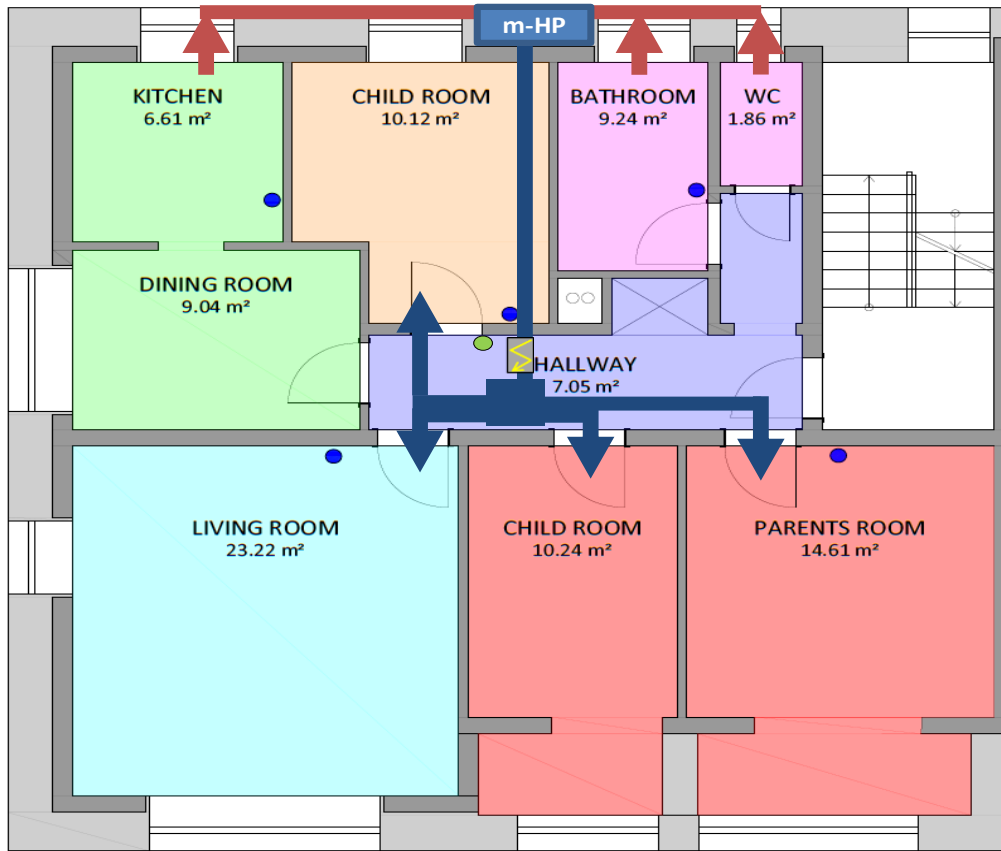


Supply Air Heat Pump



Supply-air HP

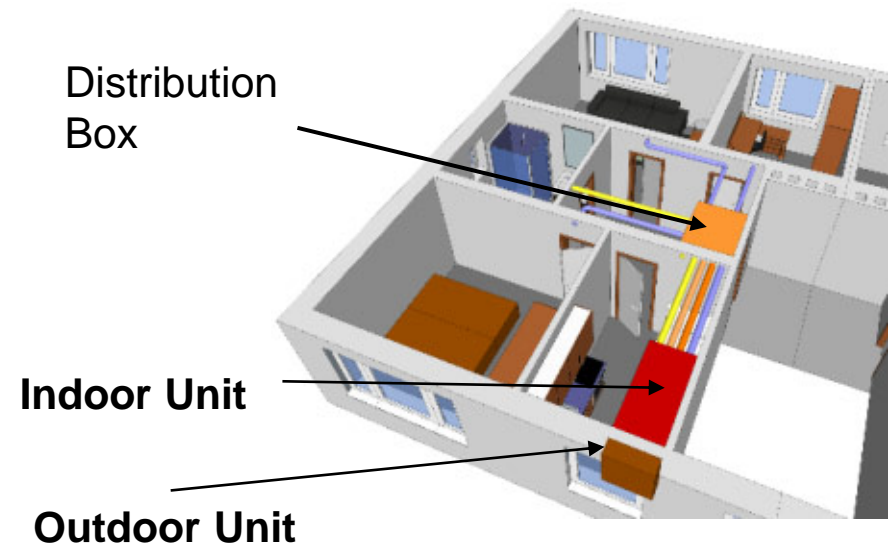
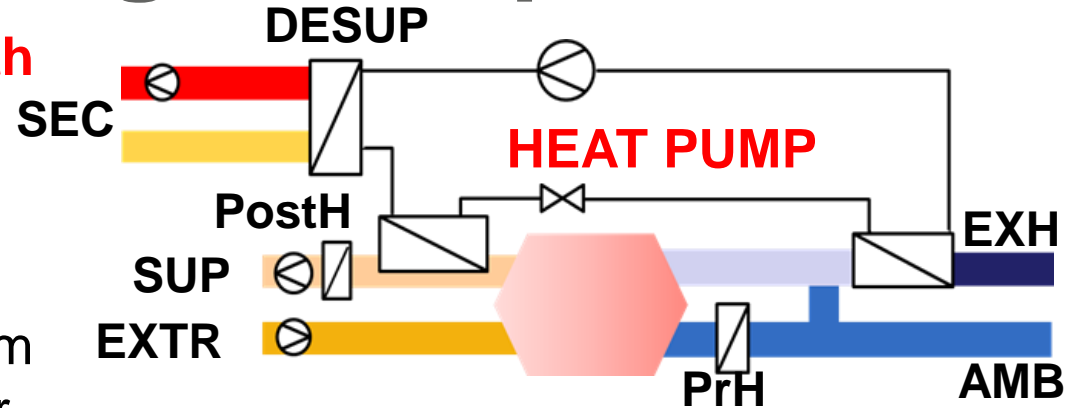
Demo Building Ludwigsburg, Germany (WB-L)



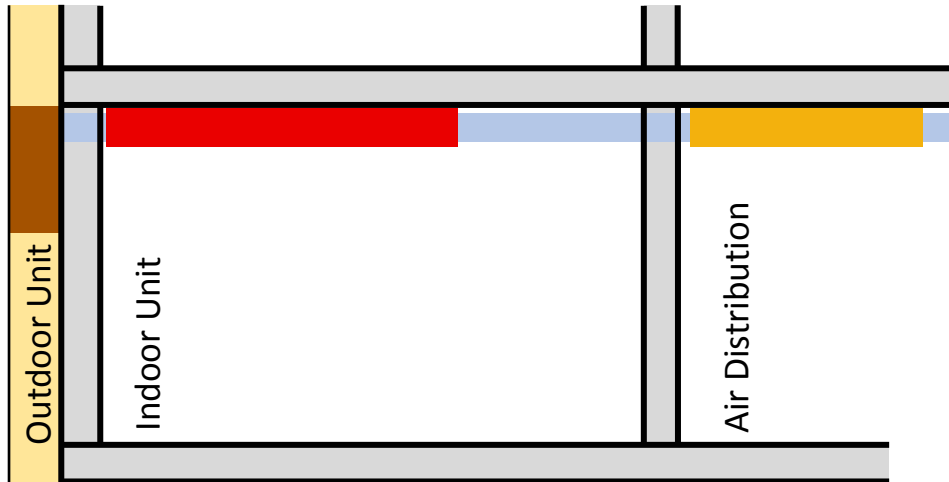
Decentral heating concepts

Supply air heat pump with secondary air recirculation

- In addition to the supply air, **secondary air** is extracted from the CO, heated in the de-superheater and supplied to the CO
- **additional ambient air** can be used as source for peak power
- Better control options through **splitting of the heating power** between supply air (condenser) and recirculation air (de-superheater)



Facade integrated HP with recirculation air



Max air temperature: 50 °C

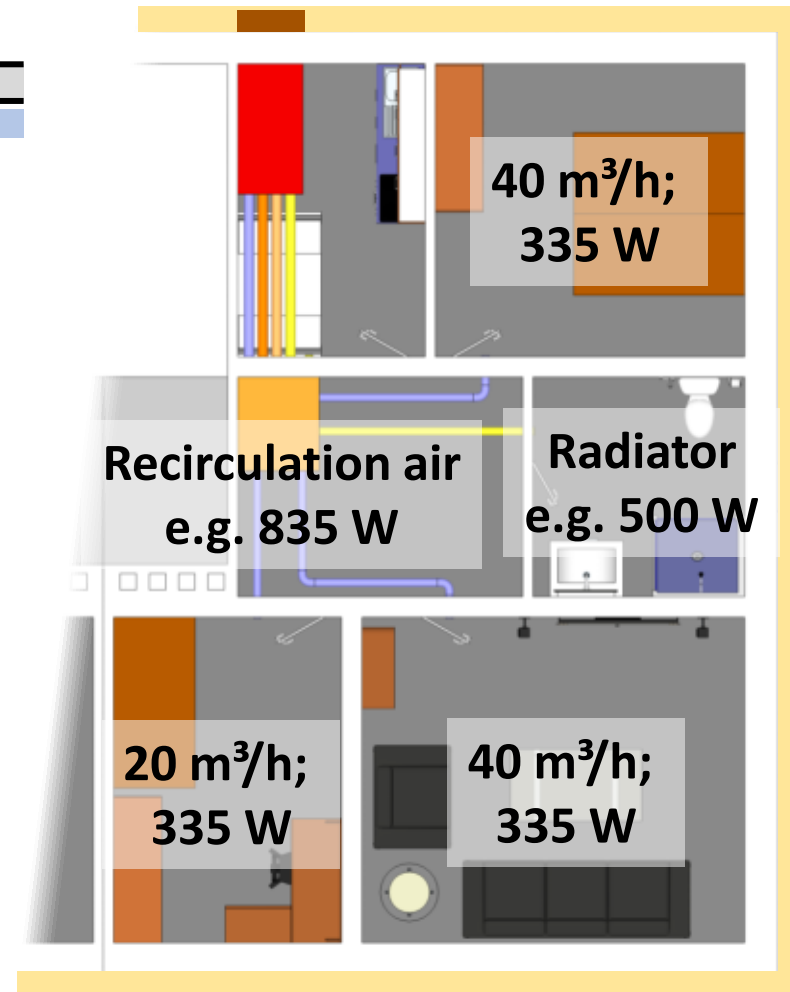
Supply air heating:

835 W, 12 W/m²

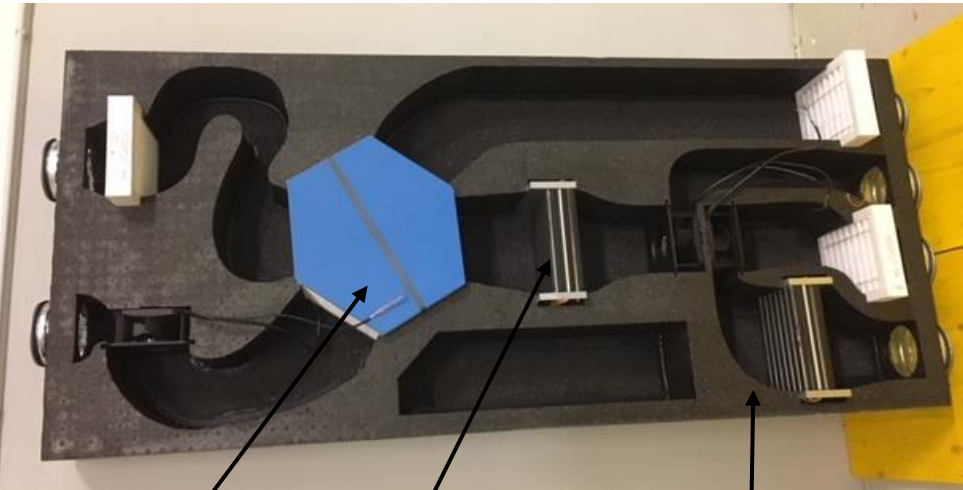
Supply air heating with recirculation air (100 m²/h):

1670 W, 24 W/m²

Bathroom radiator for reasons of comfort



Functional Model of Indoor Unit and Lab. Testing



ERV

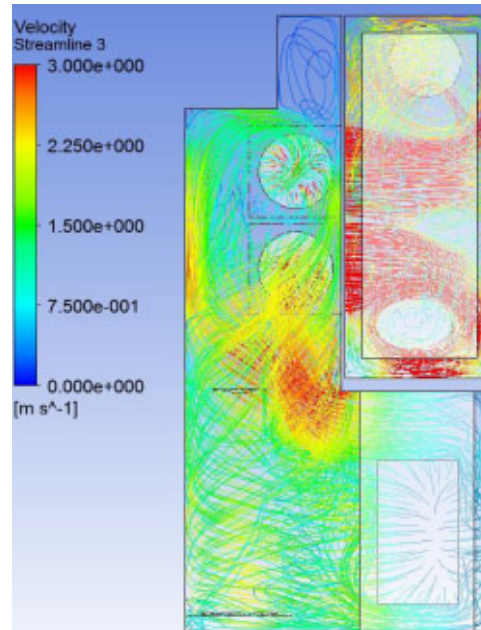
Condenser –
Supply air

Desuperheater
– secondary air

Compact Unit Test Rig at UIBK



Functional Model – Outdoor Unit, CFD and Passys



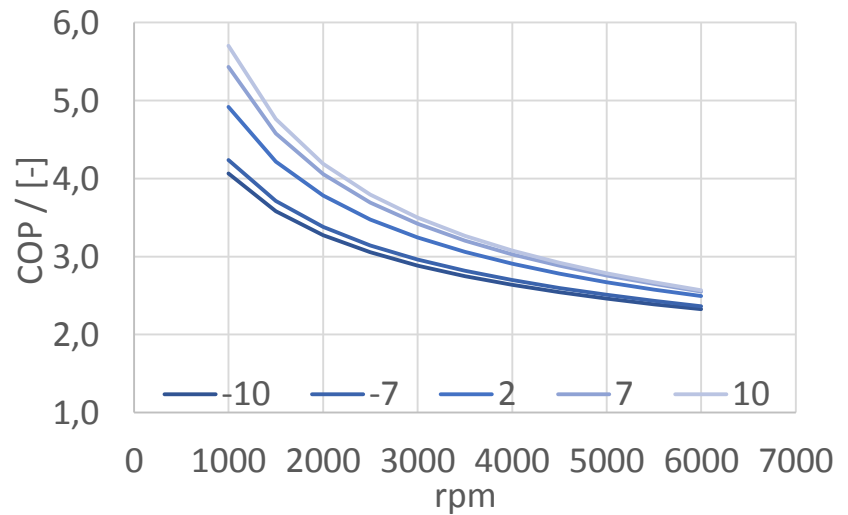
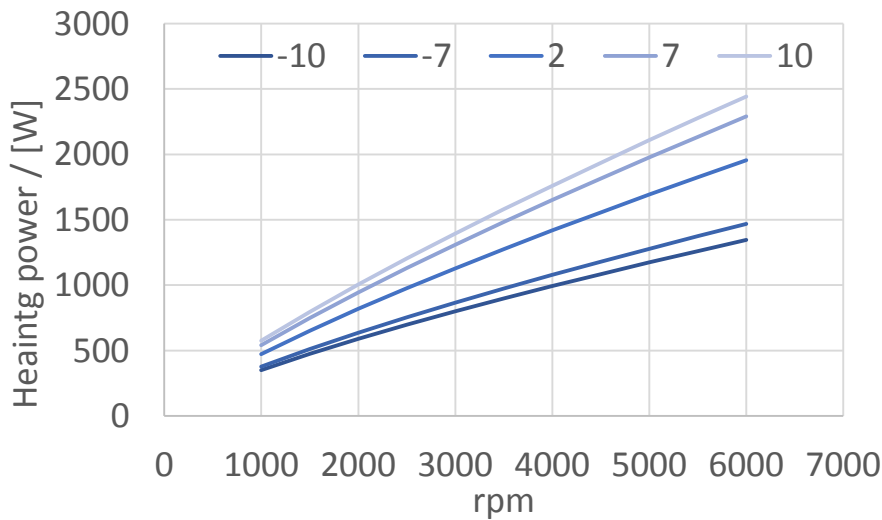
outdoor unit with evaporator and speed controlled compressor

Outside view of the outdoor unit integrated into the prefabricated timber frame facade in the Passys test cell at UIBK

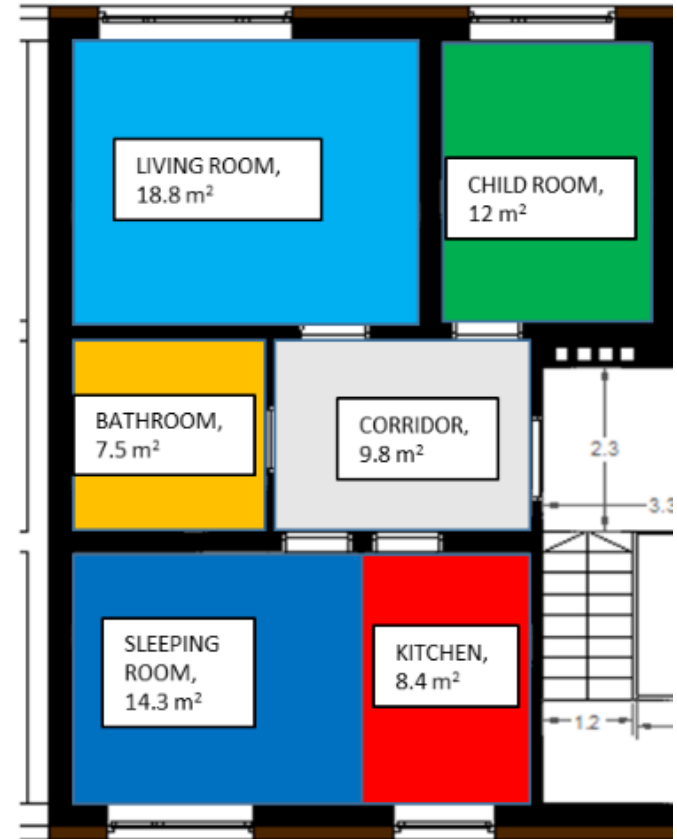
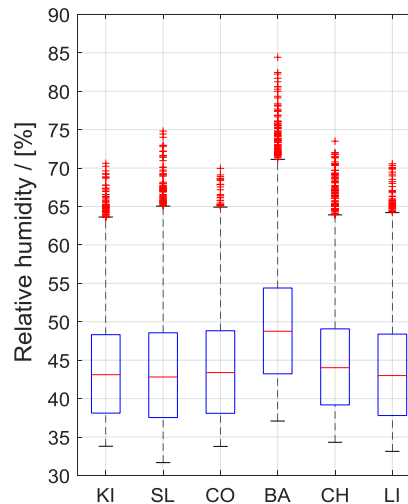
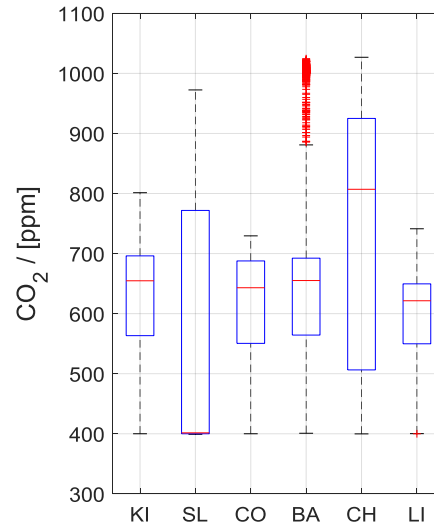
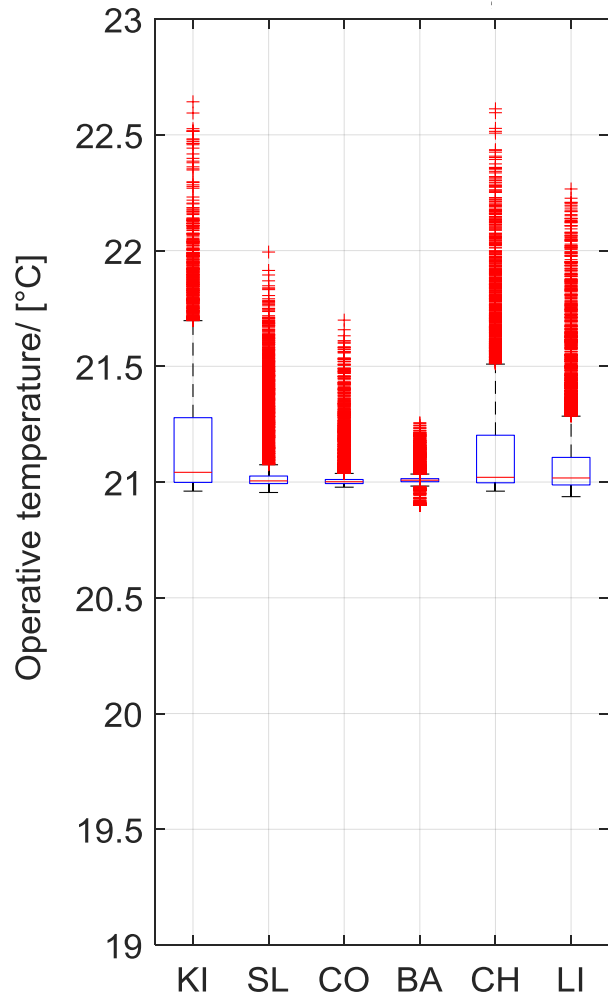
Performance Map of Heat Pump - Example

(Refrigerant Cycle Simulation based on Lab Measurements)

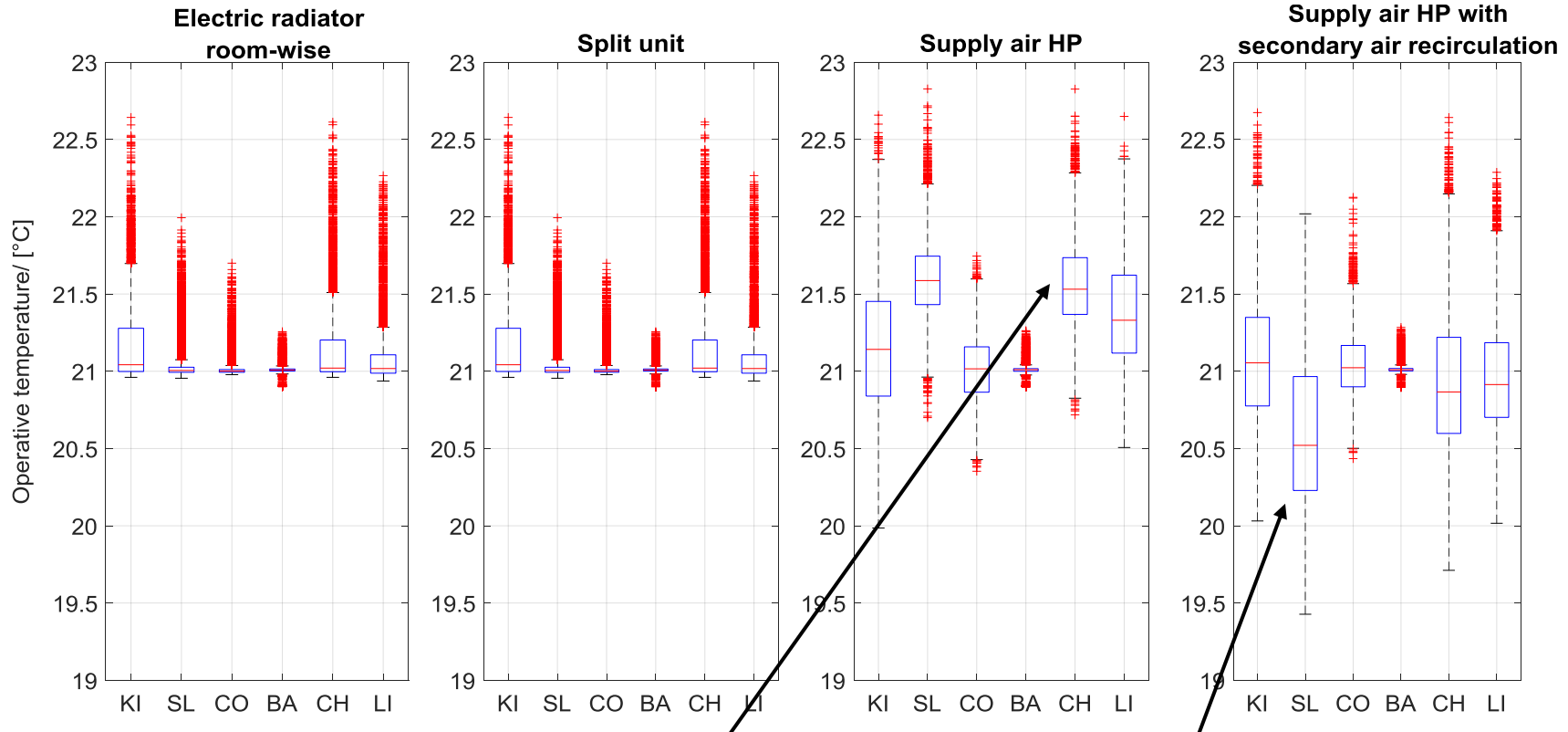
- Speed controlled HP (inverter 1000 rpm ... 6000 rpm)
- ERV
- 100 m³/h supply air
- 100 m³/h recirculation air
- 200 m³/h additional ambient air



Simulation results - Reference



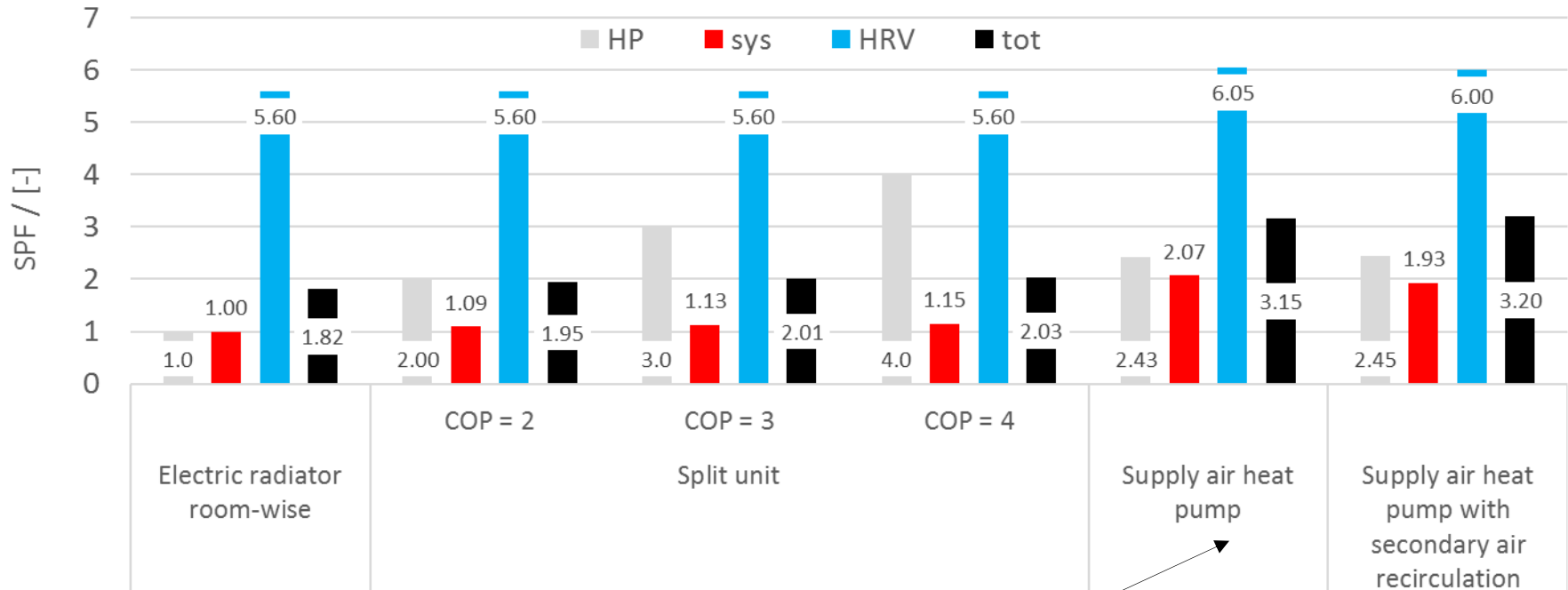
Simulation results - operative temperature (heating season)



Some overheating of supply air rooms (SL, CH and LI) due to the coupling of fresh air and heat supply

Secondary air recirculation avoids overheating, but improvement of control is needed to avoid underheating

Simulation results - System performance



Performance of system C and D are comparable, but the recirculation of secondary air adds a degree of freedom to the control of the heating system and thus overheating in supply air rooms can be avoided

Conclusions

- In the framework of the Austrian project SaLüH! compact heat pumps for deep renovated (small) flats in MFHs are developed
- Four different heating and ventilation concepts were compared to find cost-effective and energy efficient solutions
- The innovative heating concept, based on a **façade-integrated heat pump with secondary air recirculation**, adds a new degree of freedom compared to the control of supply air heat pump system
- The use of secondary air limits the overheating of supply air rooms and presents the best energy performances compared to all the others three heating concepts
- PV electricity can cover only a rel. small percentage of the electricity demand with a maximum of **26%**; additional PV on the façade must be carefully evaluated (limited additional savings of purchased electricity)

Follow-up: FFG (SdZ) project FiTNeS



FFG project FiTNeS (FFG-ID 867327)

Facade integrated modular Split-heat pump for new buildings and refurbishment

→ **Project Lead**

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01.09.2015 bis 31.08.2018.



IEA SHC Task 56

Building Integrated Solar Envelope
Systems for HVAC and Lighting



Thanks ...

