Heating with facade integrated heat pumps – results of the Austrian project „SaLüH!“

SaLüH!
Sanierungsansätze für Lüftung, Heizung und Warmwasser

Fabian Ochs

Unit for Energy Efficient Building University of Innsbruck

Fabian.Ochs@uibk.ac.at

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Canton de Berne

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Team and Partner

Team UIBK

- Toni Calabrese
- Georgios Dermentzis
- Aleksandra Ksiezyk
- Ondrej Klesnil
- Eleonora Leonardi
- Mara Magni
- Dietmar Siegele
- Christoph Speer
- Riccardo Pinotti

universität innsbruck

Arbeitsbereich für Energieeffizientes Bauen

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Partner FFG Projekt SaLüH!

- UIBK (Lead)
- AEE INTEC
- Siko Energiesysteme
- Pichlerluft
- Vaillant
- Kulmer
- Internorm

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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

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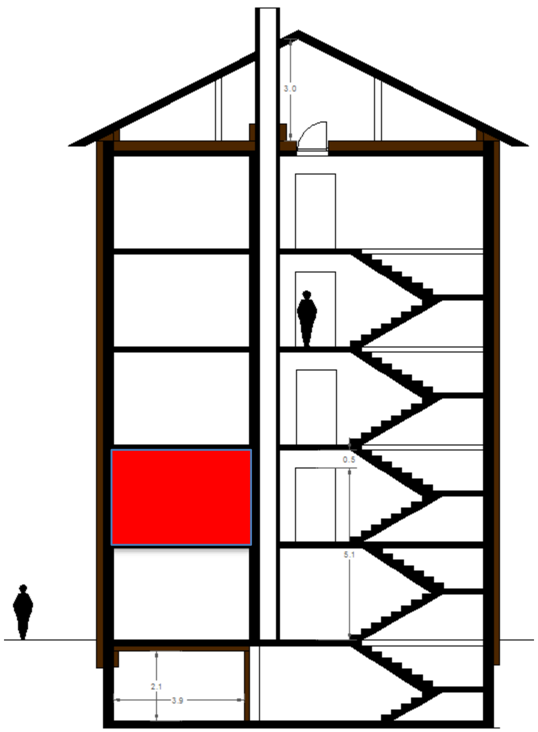
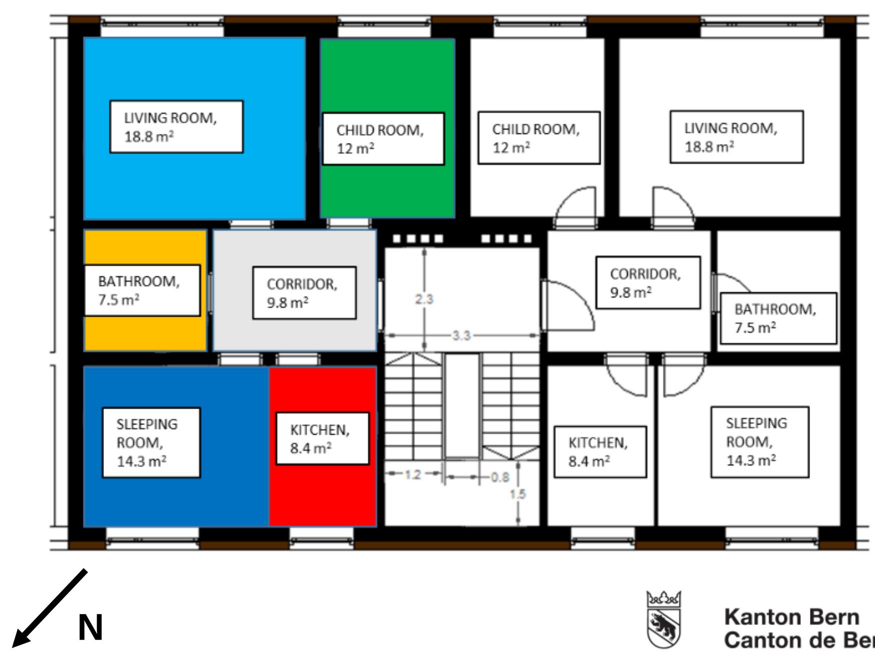
Reference Building and Model

- 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)
- The **model** (Matlab/Simulink, Carnot Blockset) of the flat consists in **six thermal zones** (one for each room), while the others flats (below, above and adjacent), basement, staircase and ambient are boundary conditions in the simulation





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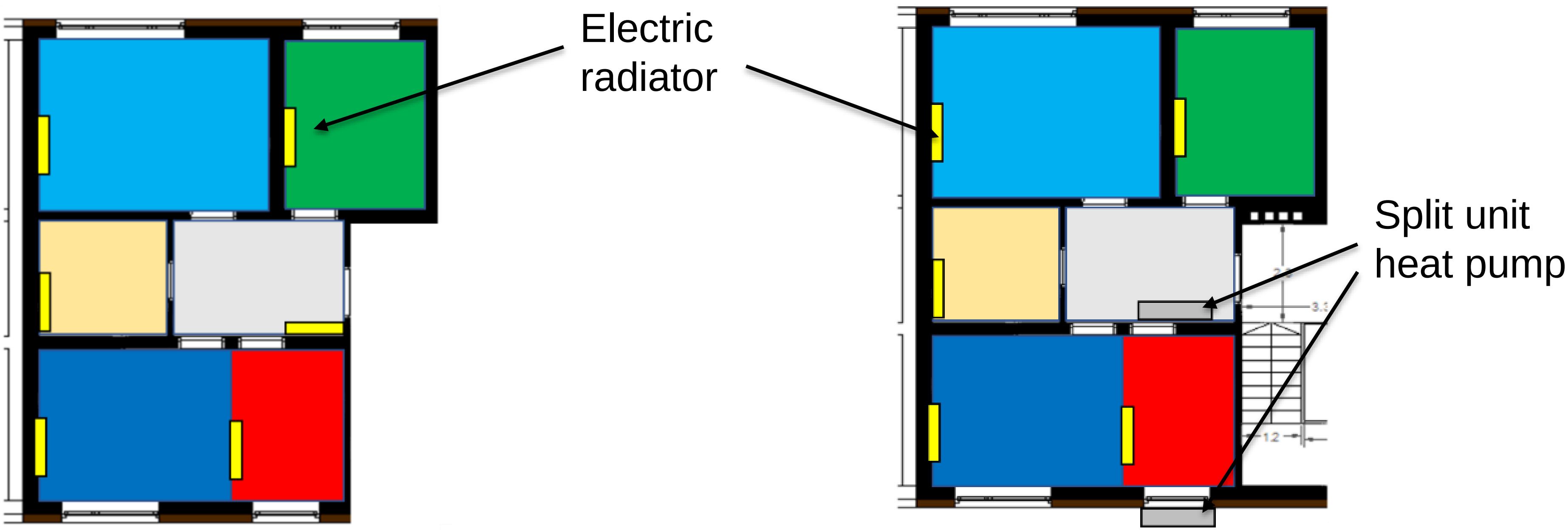
Decentral heating concepts

Different concepts for decentral heating and ventilation of small flats in renovated MFHs are investigated and compared with respect to indoor air quality (IAQ), thermal comfort (T, rH) and performance:



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 the corridor

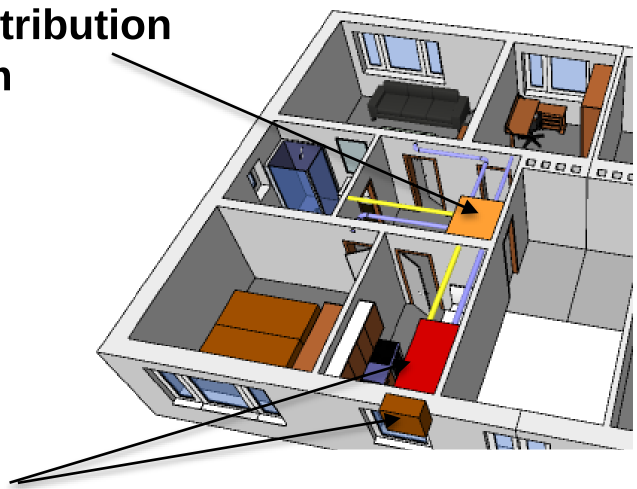
- Split unit heat pump heats the air of the CO and, indirectly, the others rooms
- Electric post-heaters are placed in all the rooms, except the CO

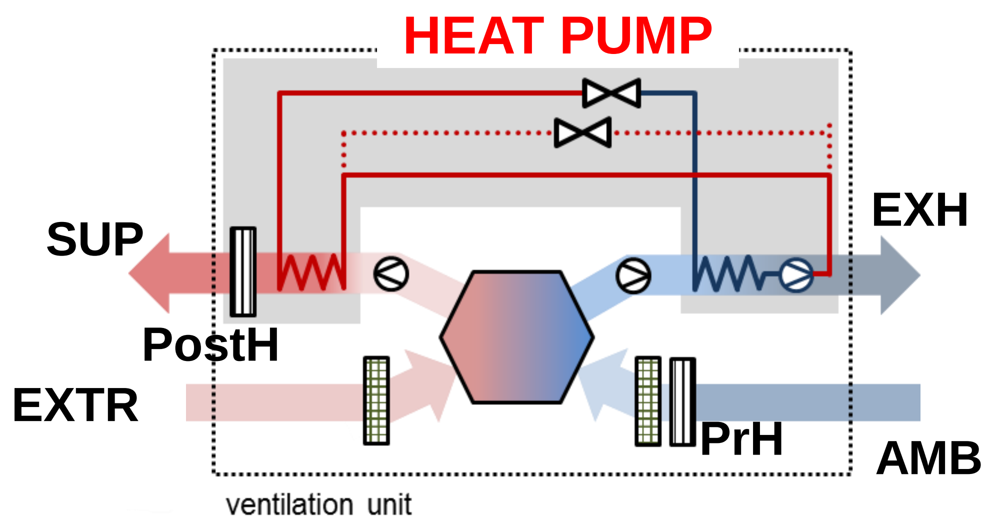
Decentral heating concepts

Supply air heat pump

iNSPiRe
Systemic energy renovation of buildings

- The ducts of the ventilation system are used to distribute space heating power, using a supply air/exhaust air heat pump system in combination with MVHR.
- The air is supplied to the SL, CH and LI and is extracted from BA and KI
- The indoor unit (with condenser and heat recovery system) and the outdoor unit (with evaporator, compressor and expansion valve) can be integrated in the façade





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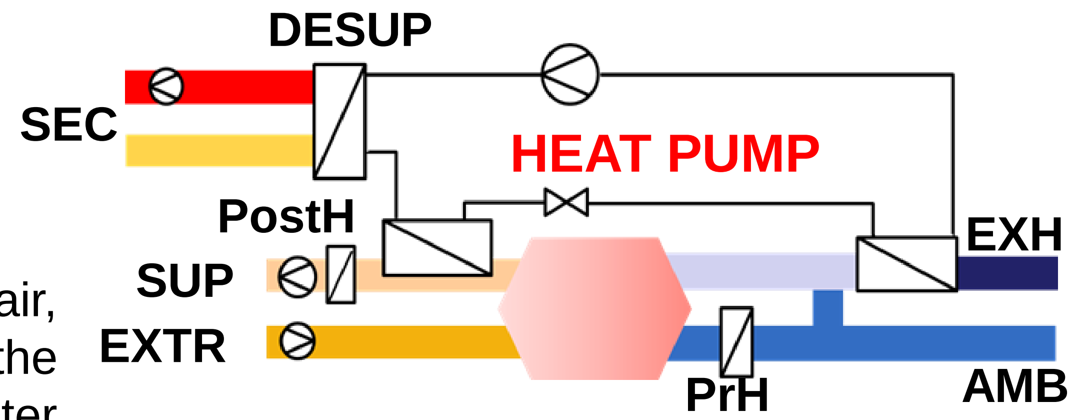
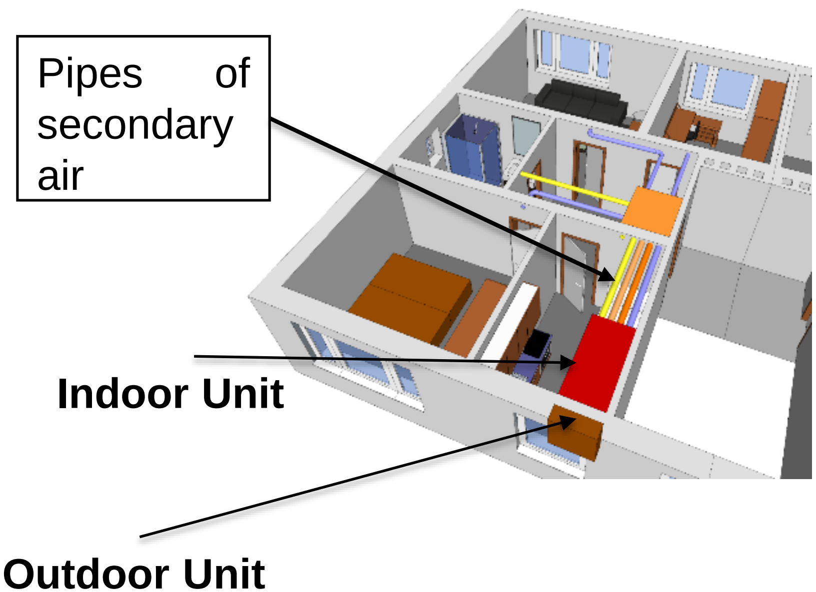
Decentral heating concepts

Supply air heat pump with secondary air recirculation

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





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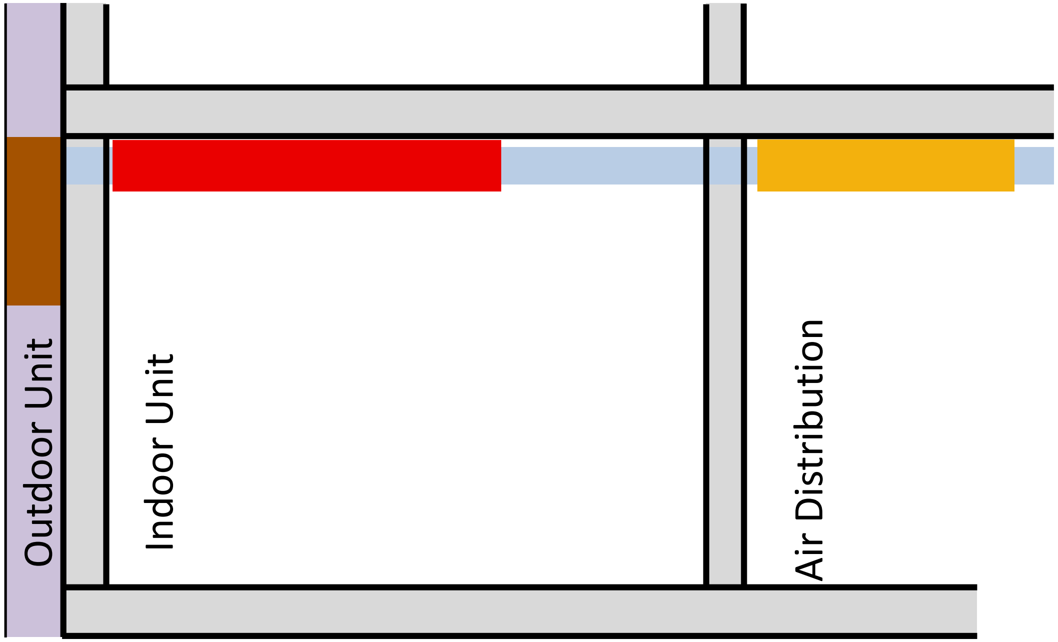
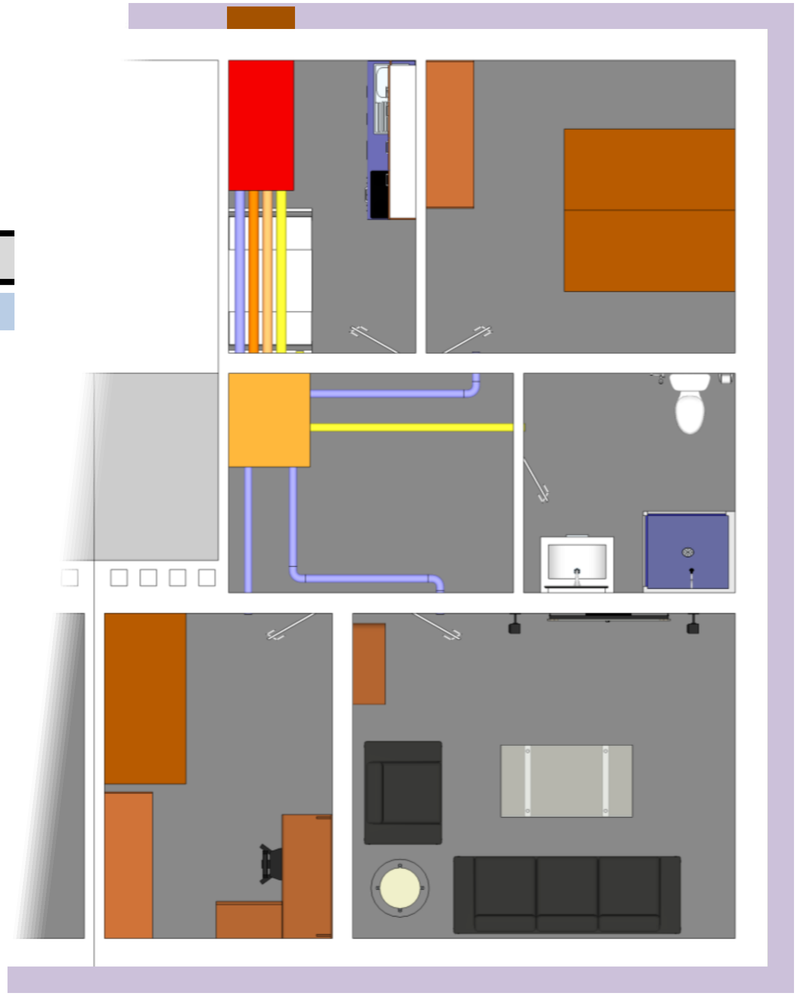
Facade integrated HP with recirculation air





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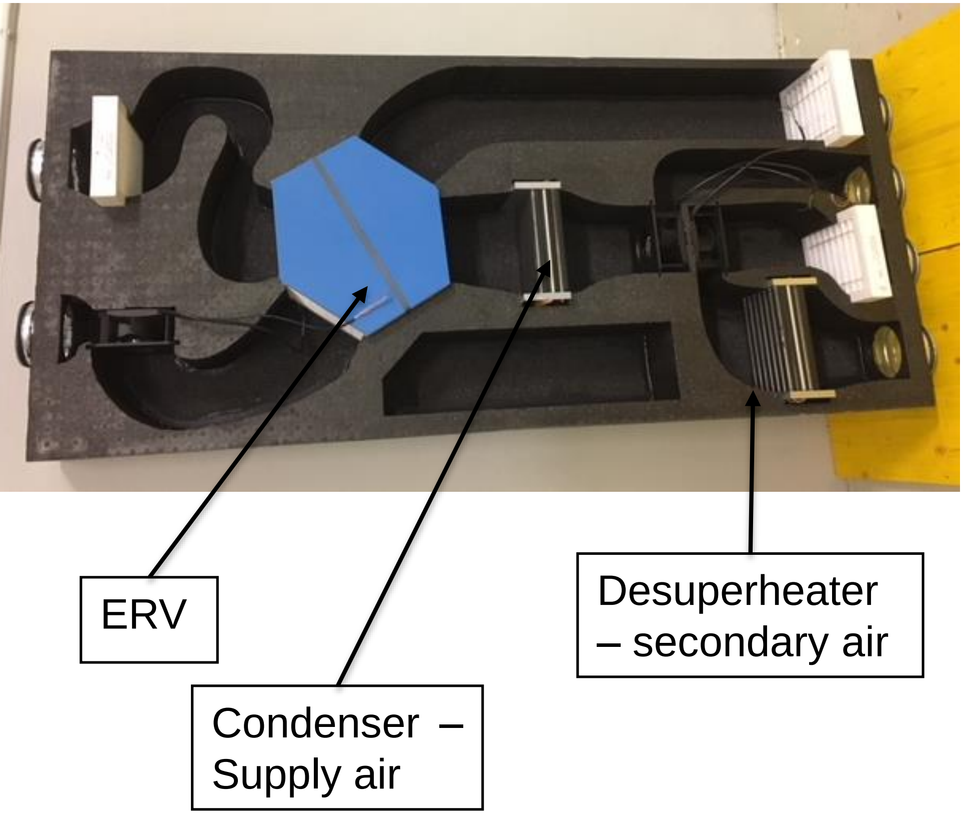
Functional Model of Indoor Unit and Lab. Testing



Compact Unit Test Rig at UIBK

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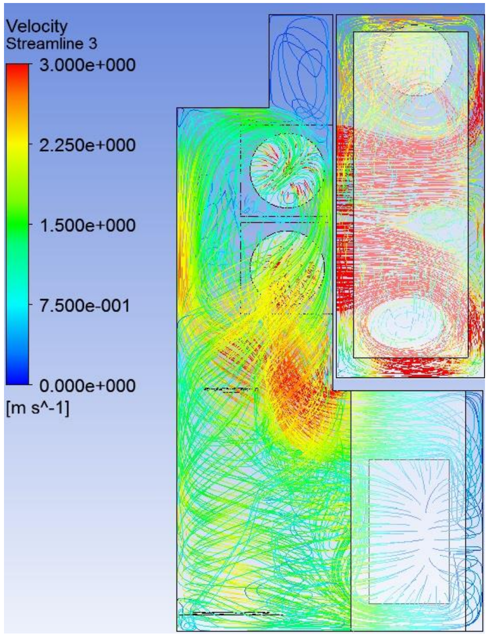
Facade Integrated Outdoor Unit

Functional Model and CFD Simulation

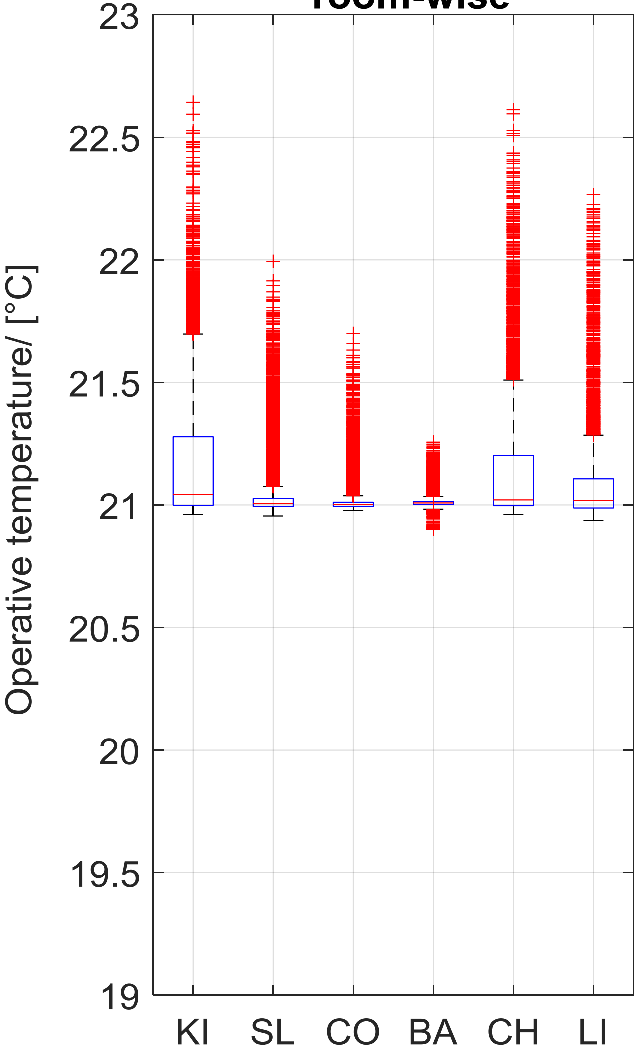


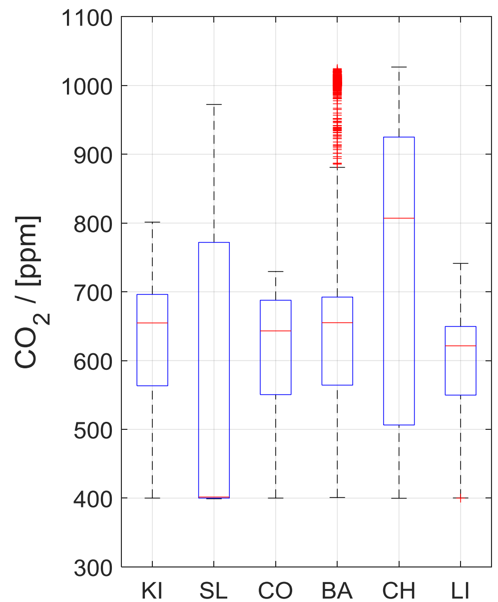
outdoor unit with evaporator and speed controlled compressor

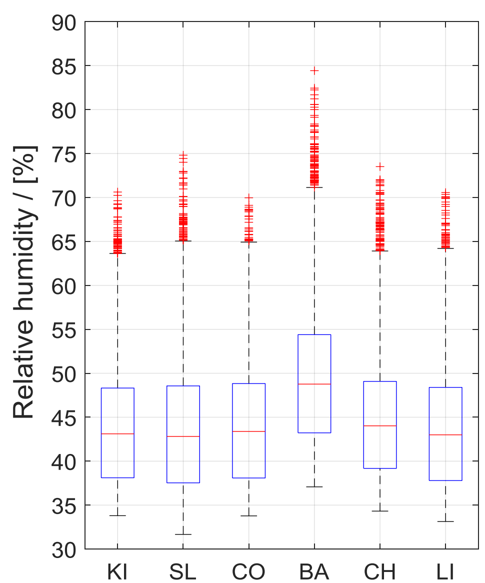
Outside view of the outdoor unit integrated into the prefabricated timber frame facade in the Passys test cell at UIBK

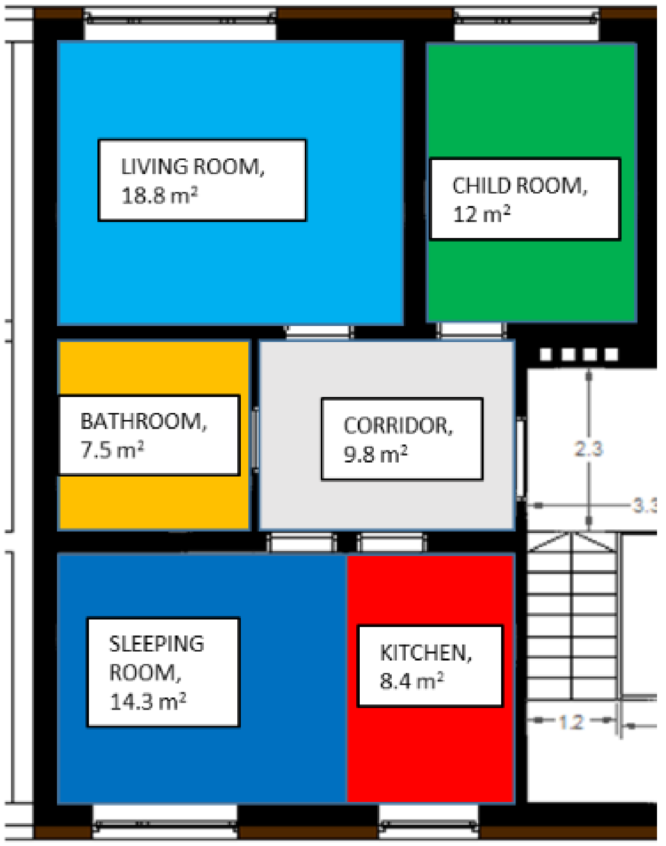
Simulation results - Reference

Electric radiator room-wise









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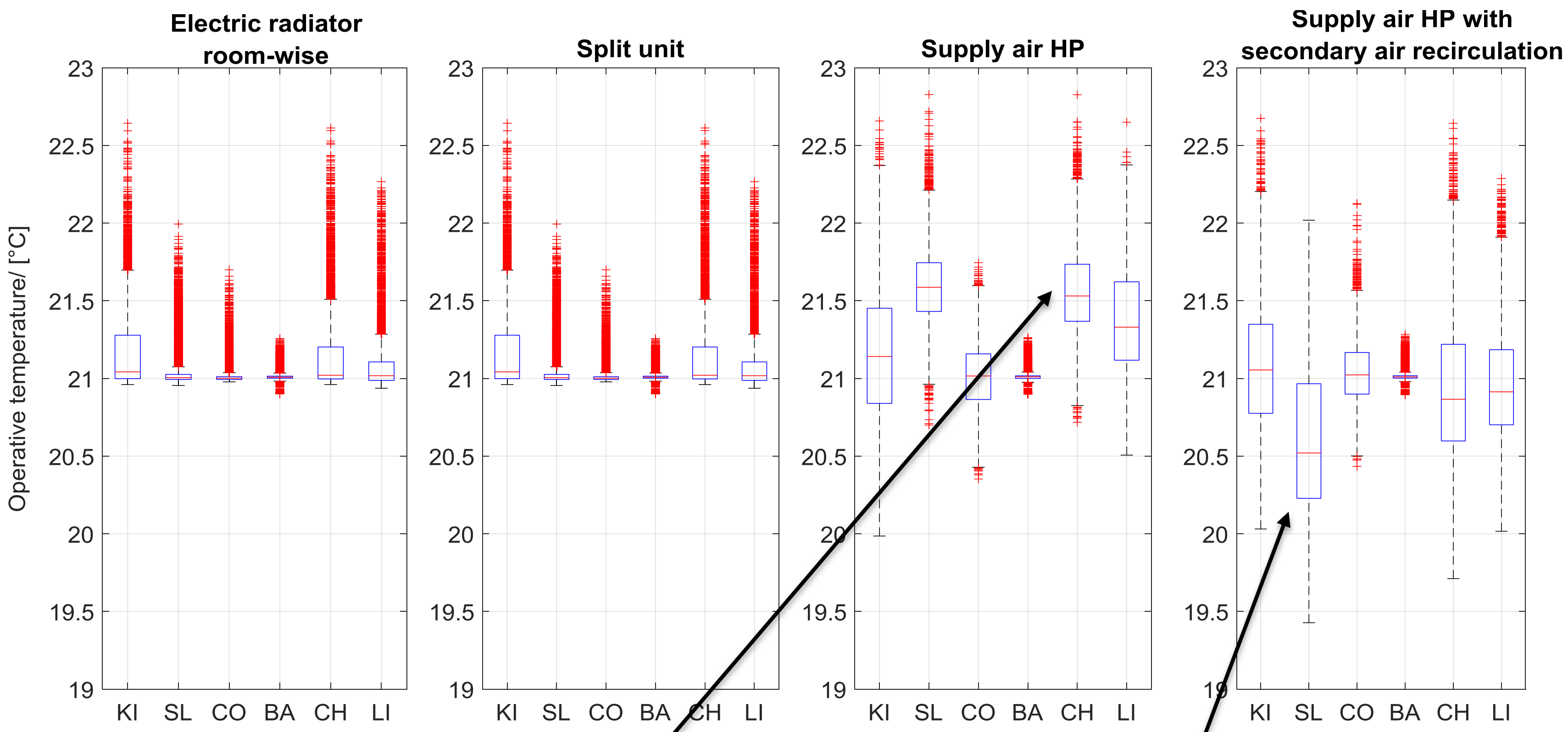
Simulation results

Operative temperature during the 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

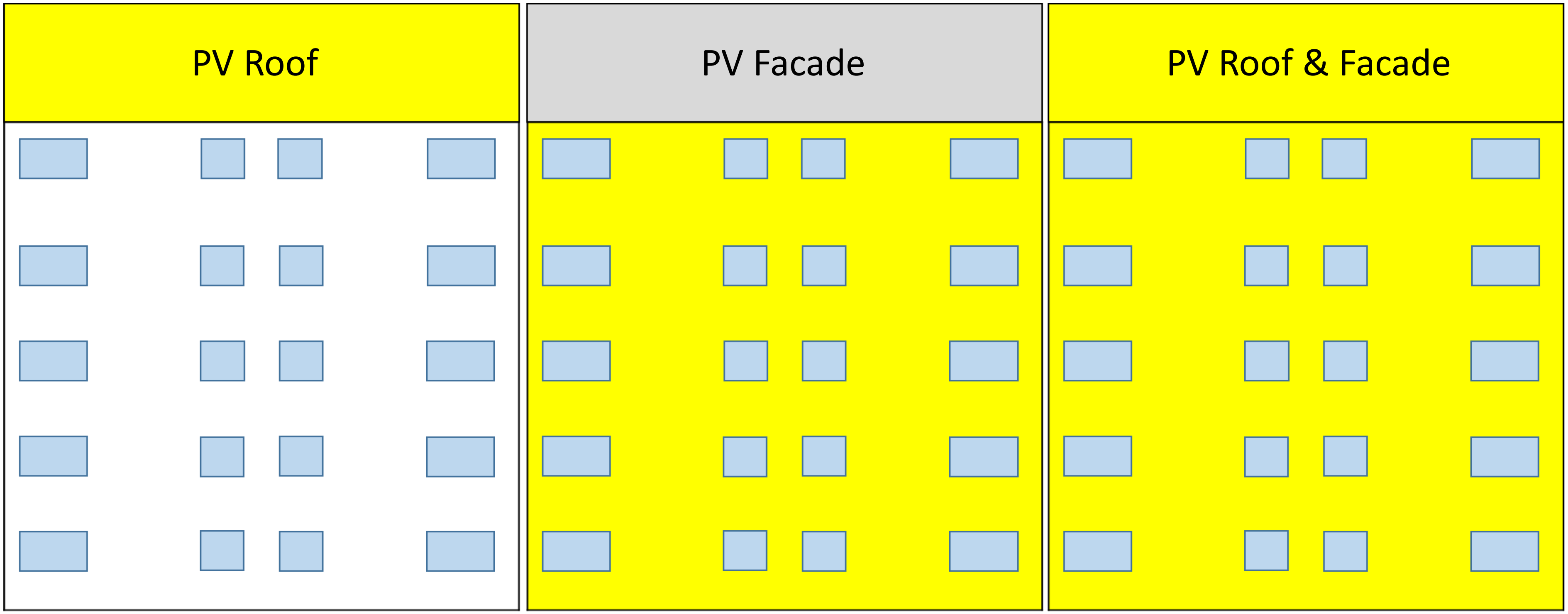
	Electric radiator room-wise (A)	Split unit (B)	Supply air HP (C)	Supply air HP with secondary air recirculation (D)
HD [kWh/(m²a)]	29.7	29.7	**30.5**	23.8
HL [W/m²]	17.2	17.2	**17.3**	14.8
EL.D [kWh/(m²a)]	29.7	27.1 / 26.3 / 25.9*	**14.8**	12.3

*in case of COP of 2, 3 or 4, respectively

- Overheating of supply air rooms in case of system „C“ explain the slightly higher HD (+3%) compared to systems „A“ and „B“
- underheating of the supply air rooms in case of system „D“ explain the lower HD (-20%) compared to systems „A“ and „B“
- Even in case of high performant split unit heat pump (i.e. COP=4), the electricity consumption of the heating system is higher compared to system „C“ and „D“

Simulation of PV Field Sizes

Potential of **covering electricity** needs of a flat **with PV –** Simulation study for different DHW profiles and PV field sizes, heating with **supply-air heat pump**



PV field sizes for each flat

	roof	façade	roof&façade
Slope	30°	90°	30° (roof) & 90° (façade)
PV size [m^2]	8.2	11.6	19.8
Peak power [W_p]	1250	1750	3000

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Simulation results

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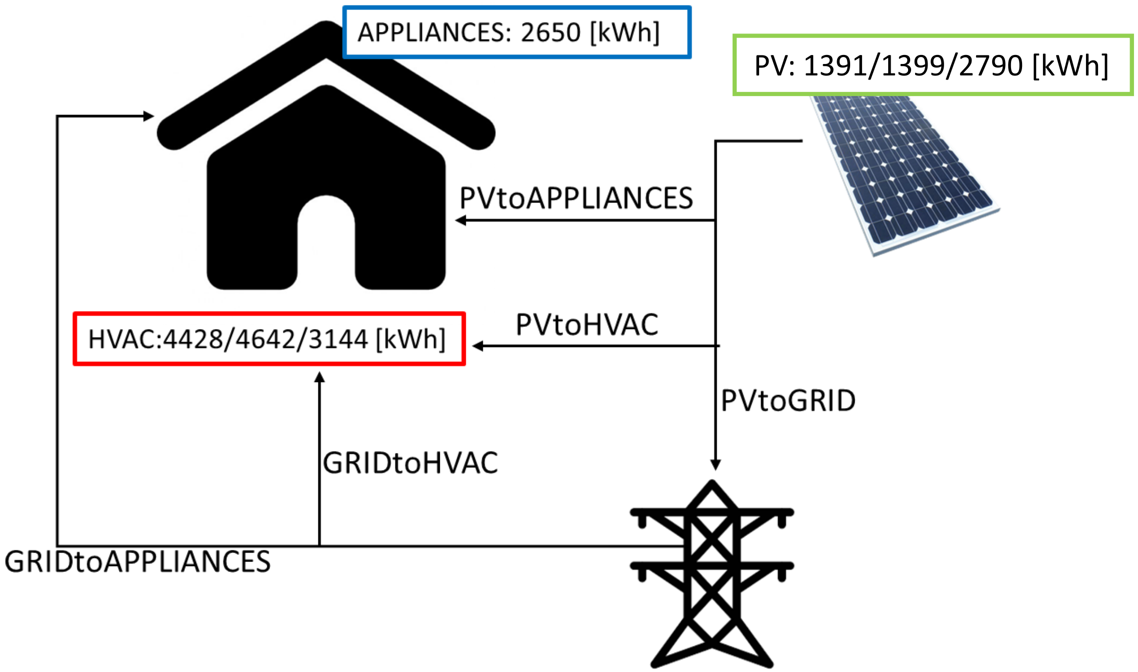


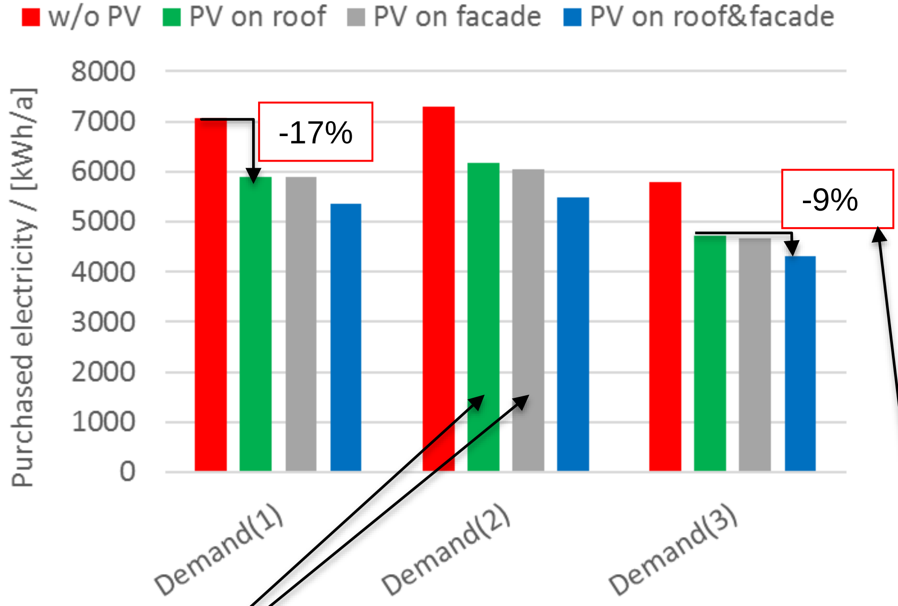
The electricity of the PV field **first covers the appliances** electricity demand and only the remaining PV electricity is available to cover the electric power demand of the HVAC system (i.e. **ventilation, heating and DHW preparation**)

HEATING: Supply air-exhaust air HP in combination with MVHR (W_{el} = 1292 kWh/a)
VENTILATION: balanced ventilation system with a constant airflow rate of 120 m^3/h (W_{el} = 946 kWh/a)

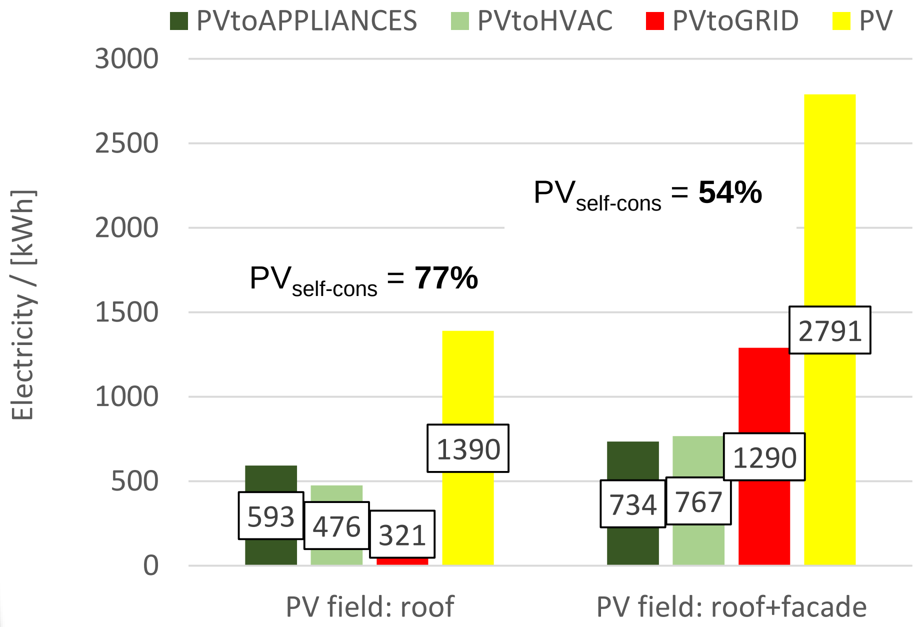
Case	Preparation	Profile	Energy [kWh/a]	Electricity [kWh/a]
DHW(1)	Electric	Flat	2190	2190
DHW(2)	Electric	Hourly	2404	2404
DHW(3)	Heat pump	Hourly	2404	906

Simulation results

Potential of covering electricity needs of a flat with PV – Simulation study for different DHW profiles and PV field sizes



Use of PV electricity – w/o storage



… with PV the purchased electricity can be reduced by 17 %

… the difference betwen PV on roof (1.25 kW_{peak} per flat) and PV on facade (1.75 kW_{peak}) is negligible.

… without energy storage the difference in purchased energy betwen PV on roof and PV on roof and facade is small with 9 %.

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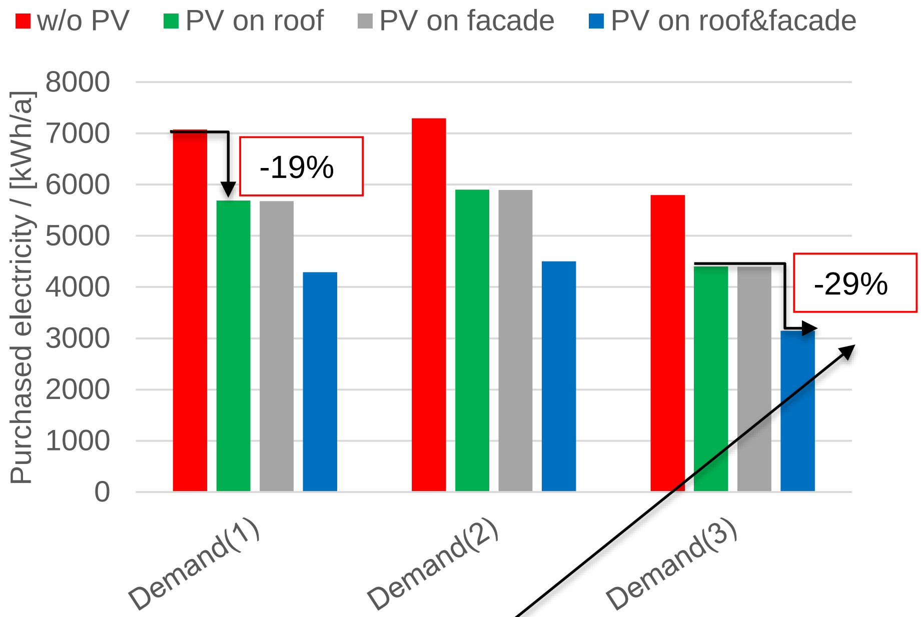
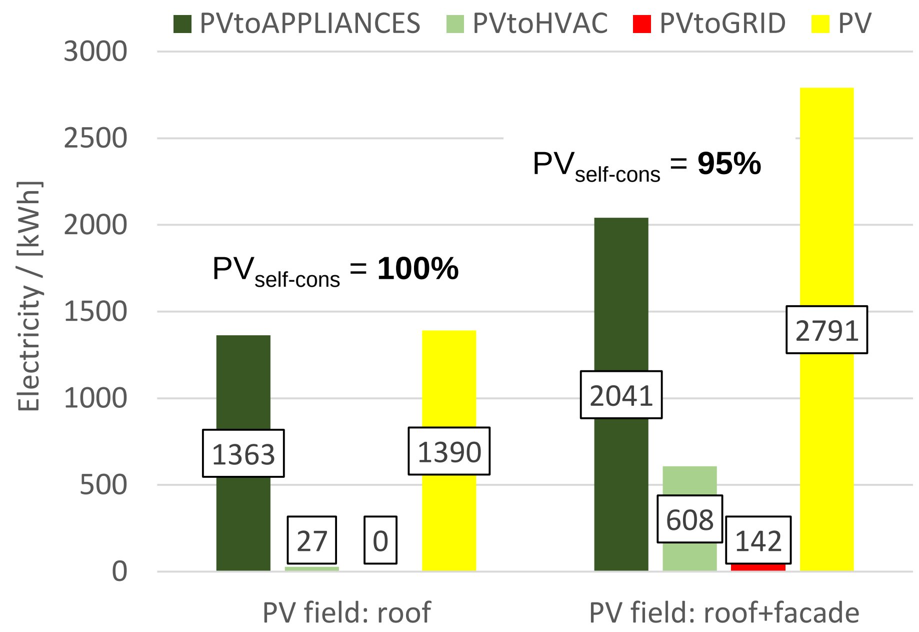
Simulation results

Potential of covering electricity needs of a flat with PV – Simulation study for different DHW profiles and PV field sizes



Use of PV electricity – **daily** storage



… with PV (roof) and daily storage the purchased electricity can be reduced by 24 %

… with additional PV on the facade it can be further reduced by 29 %
(or to 46 % with respect to the case „no PV")

… with daily energy storage (battery) the PV energy to grid can be significantly decreased from 1290 kWh to 142 kWh.

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Conclusions

- In the framework of the **Austrian project SaLüH!,** four different heating and ventilation concepts were compared to find cost-effective and efficient solutions for the **deep renovation** of small flats of MFH
- 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 a small percentage of the electricity demand with a maximum value of **26%**
- The installation of a PV on the roof or on the façade of the flat leads to the same reduction of purchased electricity
- The installation of an additional PV field on the façade must be carefully evaluated (limited additional saving of purchased electricity)
- Grid injected PV Electricity can be significantly reduced in case a **daily electric storage** is considered

Follow-up: FFG project FiTNeS

FFG project FiTNeS (FFG-ID 867327)

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

→ **Project Lead**

Universität Innsbruck
Institut für Konstruktion und
Materialwissenschaften
Technikerstraße 11/13
6020 Innsbruck

Drexel Solarlufttechnik und Lüftungsbau GmbH
Kennelbachstraße 36
6900 Bregenz

Innsbrucker Immobilien GmbH & CoKG
Rossaugasse 4
6020 Innsbruck

element design - Stephan Breier e.U.
Kleine Neugasse 7/19
1050 Wien

wInterface GmbH
Mariatrosterstraße 158
8044 Graz

Drexel und Weiss Energieeffiziente Haustechniksysteme GmbH
Achstraße 42
6922 Wolfurt

Ingenieurbüro Rothbacher GmbH
Am Schilf 15
5700 Zell am See

FFG Forschung wirkt.

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Canton de Berne

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SaLüH!

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FFG Projekt 850085 (Stadt der Zukunft, 2. Ausschreibung)

01.09.2015 bis 31.08.2018.

IEA SHC Task 56

Building Integrated Solar Envelope Systems for HVAC and Lighting