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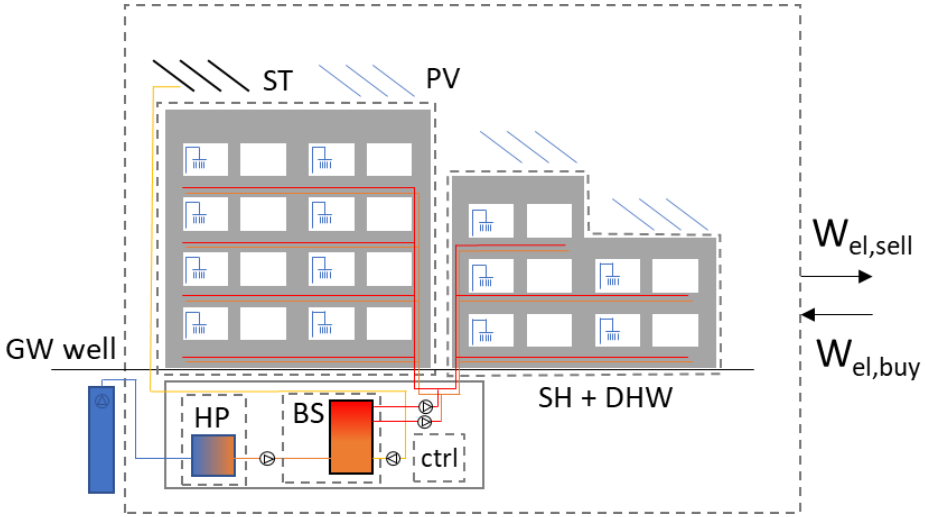
Optimizing HP Systems for MFH with CarnotUIBK / Carnot / Simulink

HP_App&Sim, Carnot User Meeting 2023, Bologna

Ochs, Fabian, Assoc. Prof. Dr.-Ing.

Optimizing HP Systems for MFH with CarnotUIBK / Carnot / Simulink

Fabian Ochs, Georgios Dermentzis, Mara Magni, William Monteleone, Elisa Venturi,
Samuel Breuss, Nicola Franzoi, Stefano Fisco, …



NZEB: $W_{el,buy} = W_{el,sell}$

$W_{el,sell} = W_{el,PV} - W_{el,PVown}$

$W_{el,buy} = W_{el} - W_{el,PVown}$

$W_{el} = W_{el,HP(SH)} + W_{el,HP(DHW)} + W_{el,aux}$

in [kWh/(m² a)]	Design	Monitored	Optimized
$W_{el,sell}$	7.4	7.4	7.4
$W_{el,buy}$	3.7	12.4	7.1

F. Ochs, N. Franzoi, G. Dermentzis, W. Monteleone, M. Magni, **Monitoring and Simulation-Based Optimization of two Multi-Apartment NZEBs with Heat Pump, Solar Thermal and PV**, Journal of Building Performance Simulation, 2023, 10.1080/19401493.2023.2227605 (accepted)

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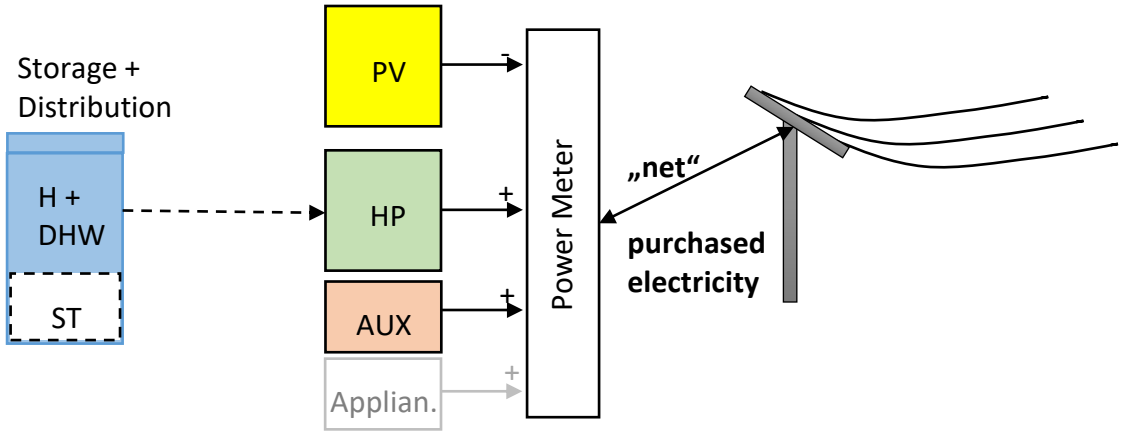
Content

- Introduction (MFH NZEB: HP + PV (+ST))
  Case Study (NZEB Vögelebichl, Innsbruck)
- Fault Detection and Optimisation
- Simulation on Component and System Level
- Simulation assisted Optimisation
- Conclusions and Outlook



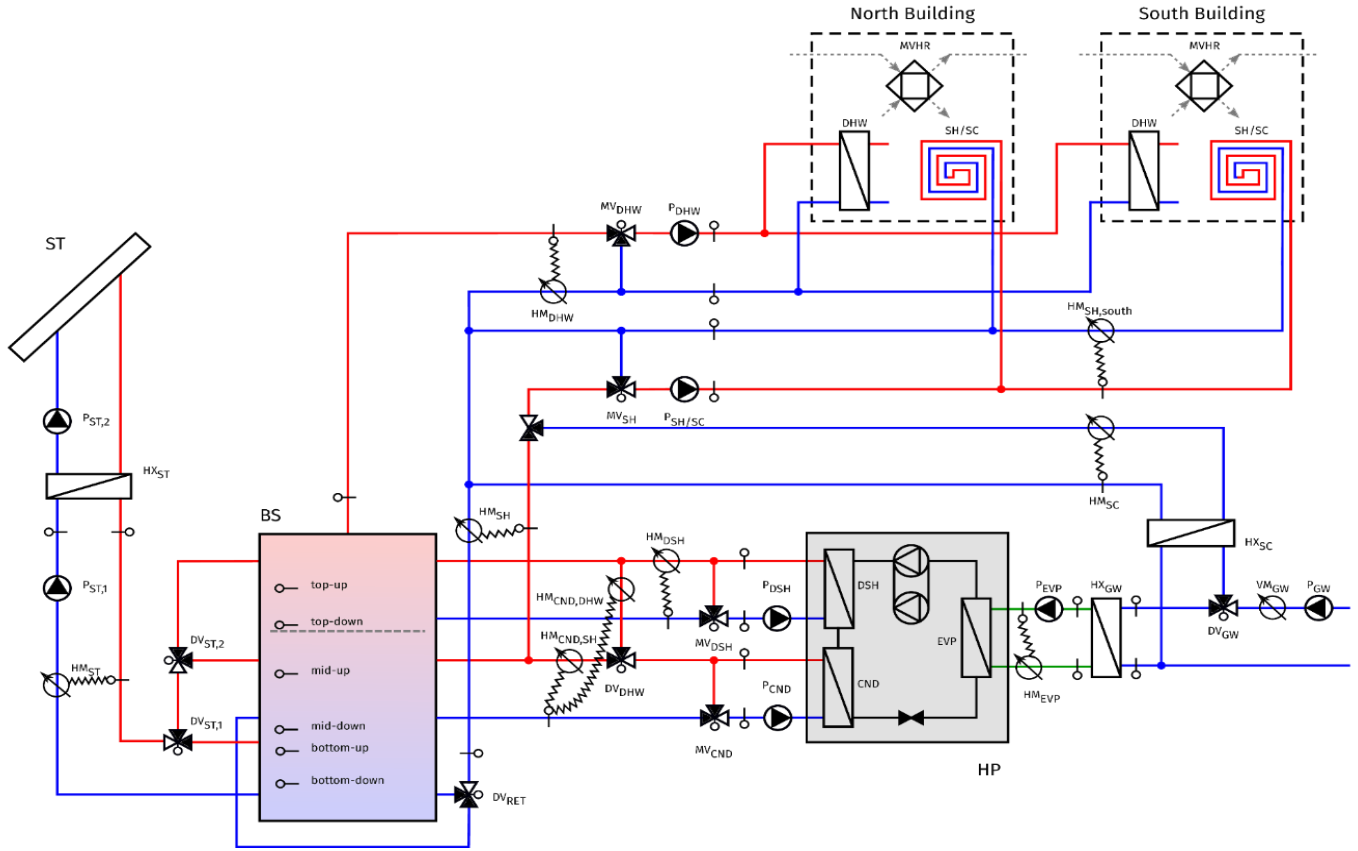
Ochs, F., Dermentzis, G., & Monteleone, W. (2019). Simulation-assisted Optimization of the HVAC system of NZE Multi-family Buildings. In 16th IBPSA Conference Rome (pp. 4961-4968). Italy Rome, Italy.

NZEN Vögelebichl (NHT)

NZEB (Net Balance, SH + DHW + AUX (+APP))

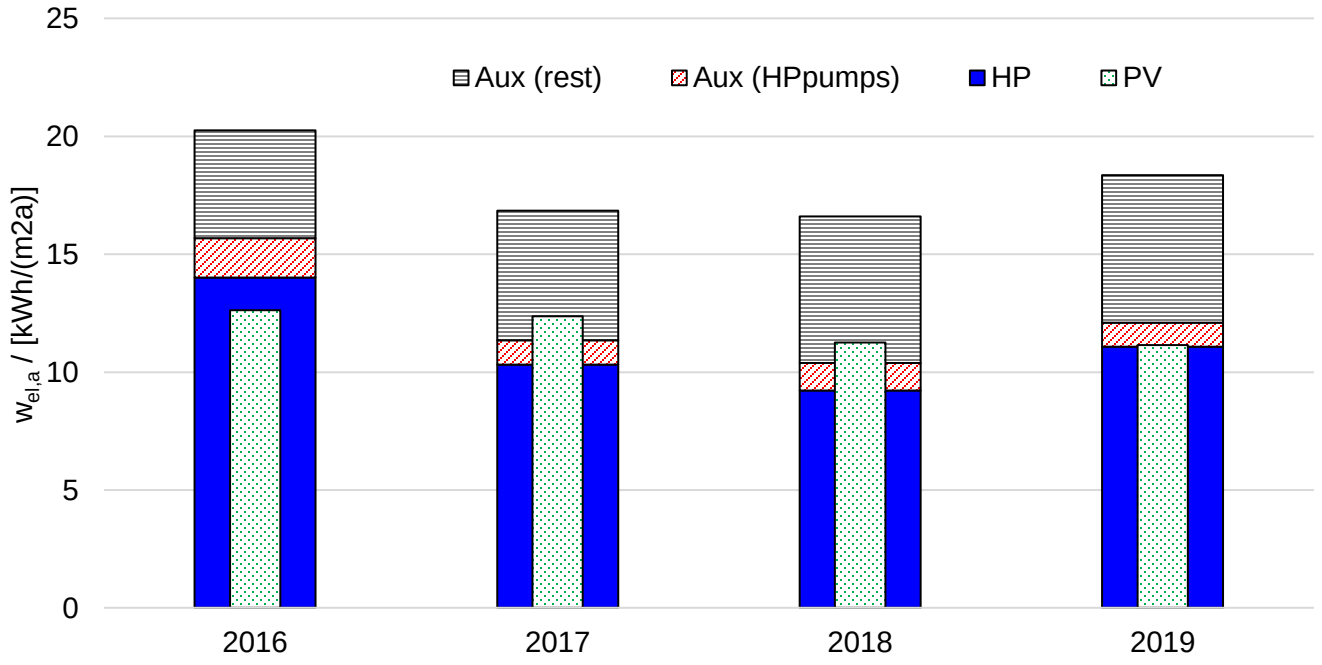
- PH standard (PH Plus certified)
  (Min. SH demand)
- GW Heat Pump (double stage)
- 2+2 pipe system
  (Min. losses, max. HP efficiency)
- PV (and ST) on roof (and facade)
- Minimal Aux Electricity
- Max. efficient appliances

NZEB w/ Heat Pump System with PV and ST



Ochs, F., Dermentzis, G., & Feist, W. (2014). Minimization of the residual energy demand of multi-storey passive houses–energetic and economic analysis of solar thermal and PV in combination with a heat pump. Energy Procedia, 48, 1124-1133.

NZEB - Monitoring Results



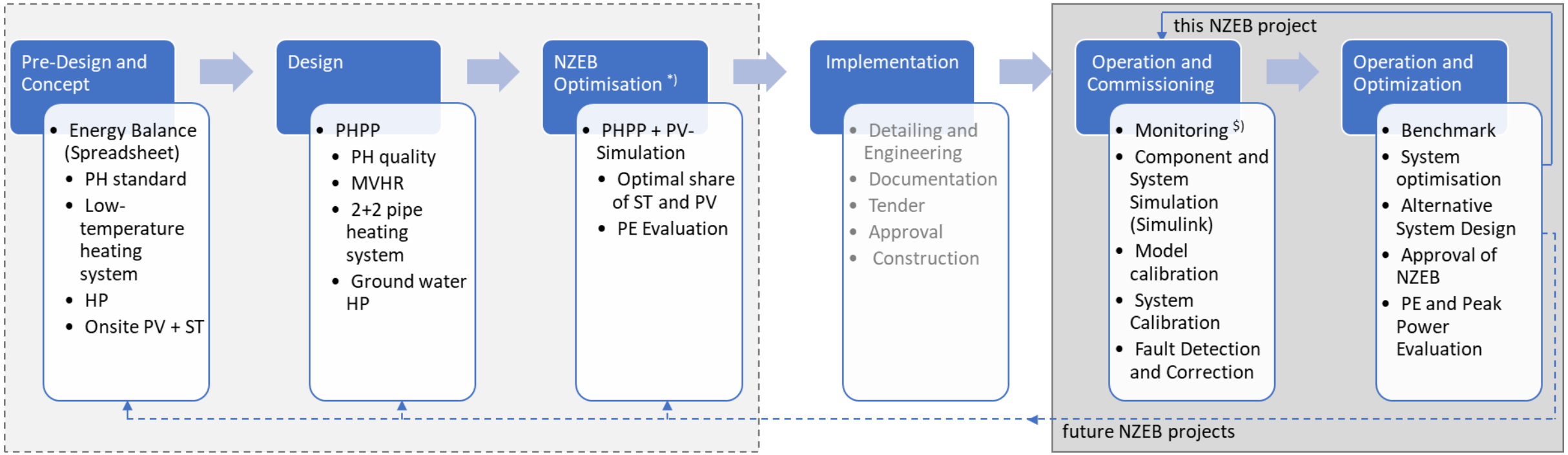
Dermentzis, G., Ochs, F., & Franzoi, N. (2021). Four years monitoring of heat pump, solar thermal and PV system in two net-zero energy multi-family buildings. Journal of Building Engineering, 43, 103199.

NZEB not achieved!

Why?

Can it be achieved?
With this concept?
Are there better ones?
What about the winter gap?

Design and Optimization process



Design and Optimization process of the NZEB with path 1 this NZEB project and path 2 future NZEB projects *) (Ochs, Dermentzis and Feist, 2014),$) (Dermentzis, Ochs and Franzoi, 2021)

F. Ochs, N. Franzoi, G. Dermentzis, W. Monteleone, M. Magni, Monitoring and Simulation-Based Optimization of two Multi-Apartment NZEBs with Heat Pump, Solar Thermal and PV, Journal of Building Performance Simulation, 2023, 10.1080/19401493.2023.2227605 (accepted)

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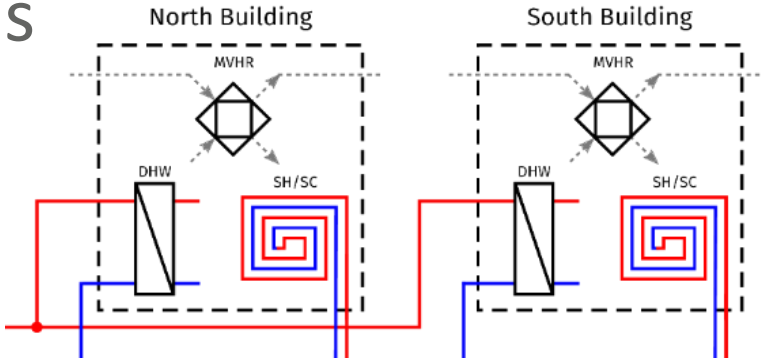
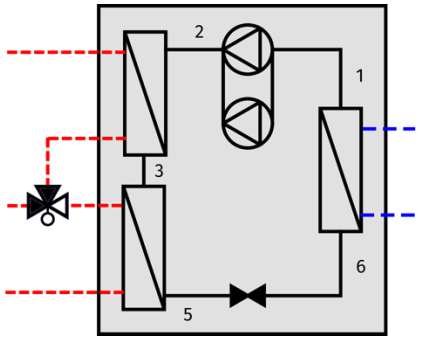
Component Models

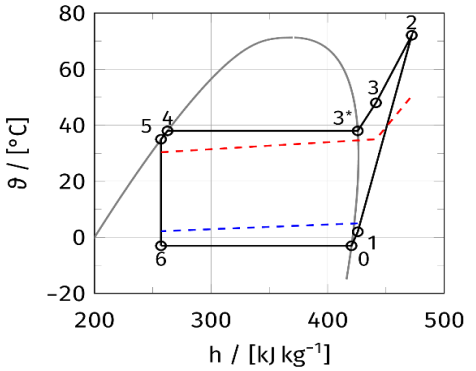
» Building



- Heating Demand
- DHW Demand
- Indoor Air Temperature

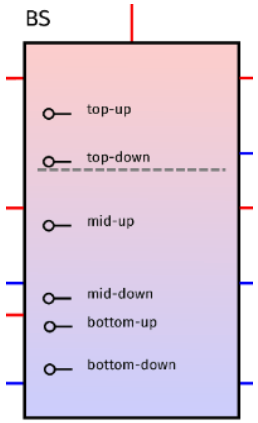
» Heat Pump





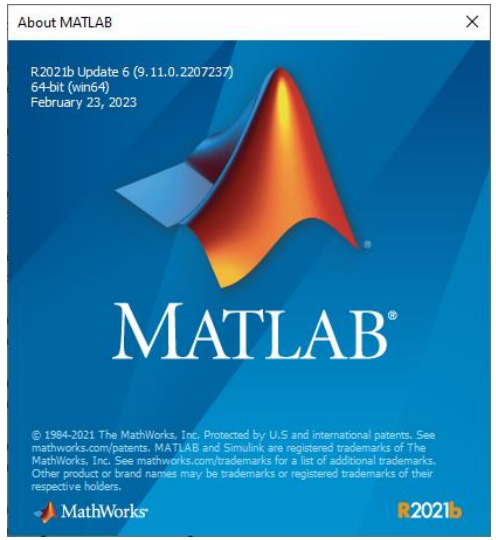
- Performance MAP (Power, COP)
- Desuperheater
- 2 stage Control

» Buffer Store

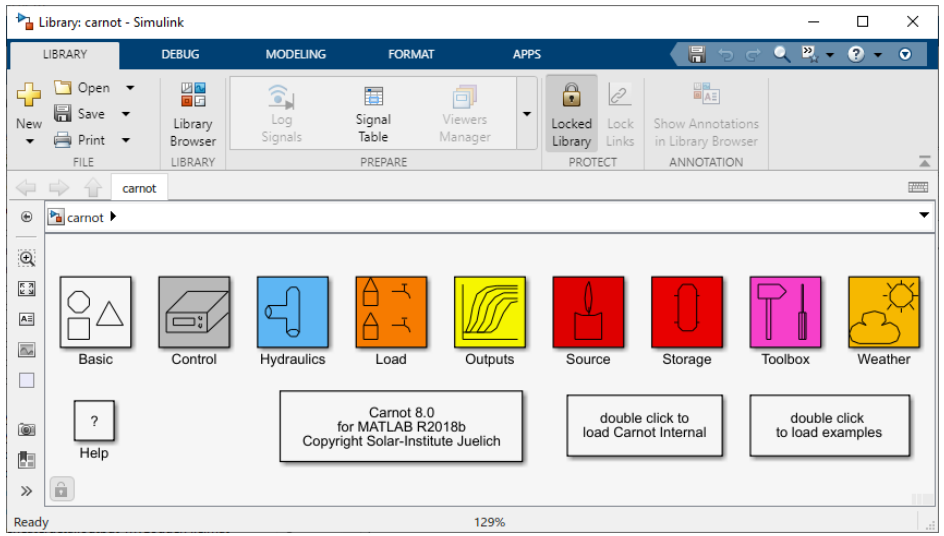


- Thermal Losses
- Stratification

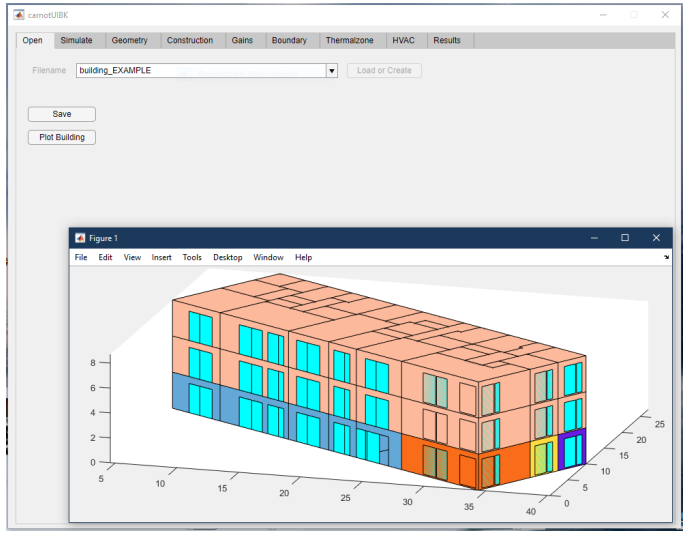
Matlab/Simulink - CarnotUIBK and Carnot Toolbox and PHPP



https://de.mathworks.com/



https://www.fh-aachen.de/forschung/institute/sij/carnot



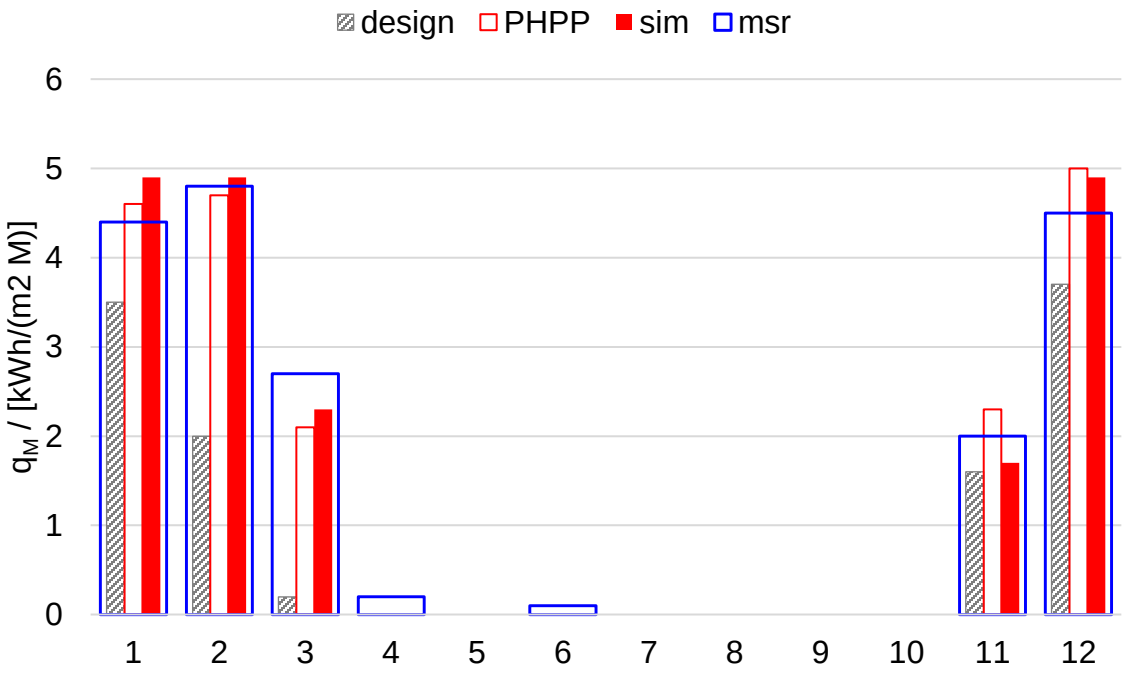
https://www.uibk.ac.at/bauphysik/forschung/carnotuibk/index.html.en

Siegele, D., Leonardi, E., & Ochs, F. (2019, September). A new MATLAB Simulink Toolbox for Dynamic Building Simulation with BIM and Hardware in the Loop compatibility. In Building Simulation Rome, 2019 IBPSA

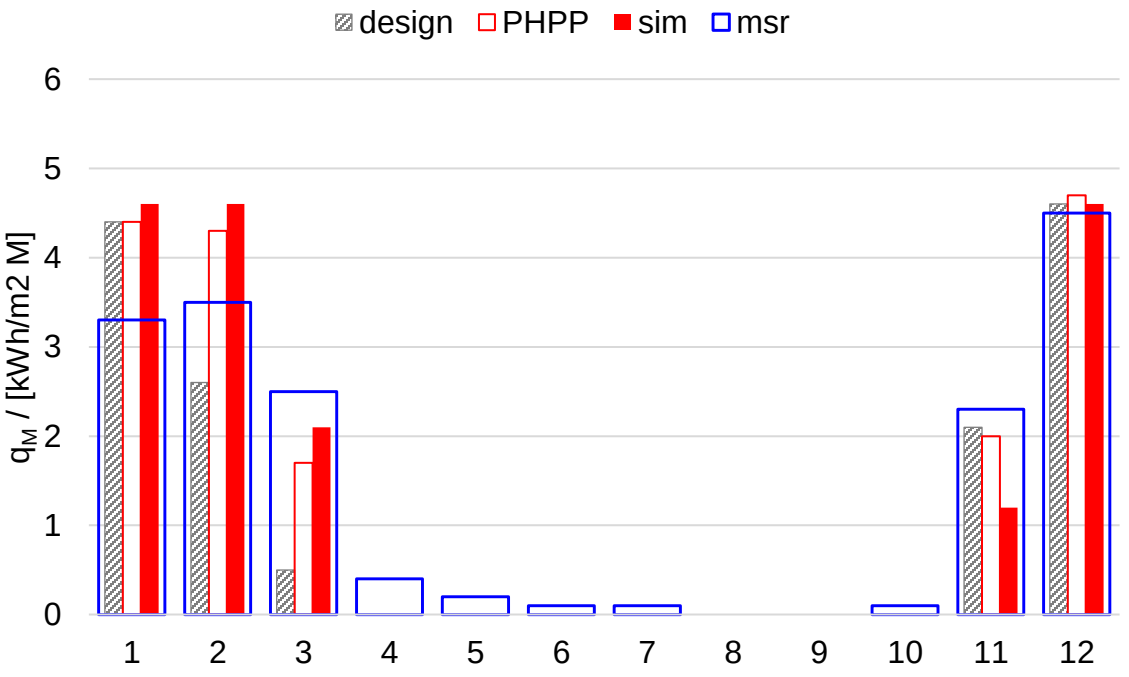
Dermentzis, G., Ochs, F., Gustafsson, M., Calabrese, T., Siegele, D., Feist, W., ... & Bales, C. (2019). A comprehensive evaluation of a monthly-based energy auditing tool through dynamic simulations, and monitoring in a renovation case study. Energy and Buildings, 183, 713-726.

https://passiv.de/de/04_phpp/04_phpp.htm#PH9

Building (CarnotUIBK) – Monthly Space Heating Demand



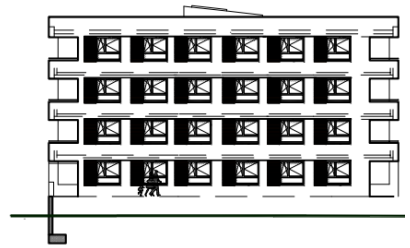
North Building

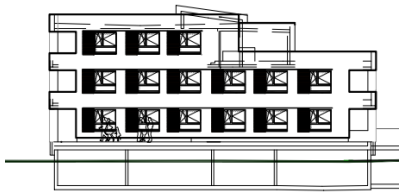


South Building monitored in 2018

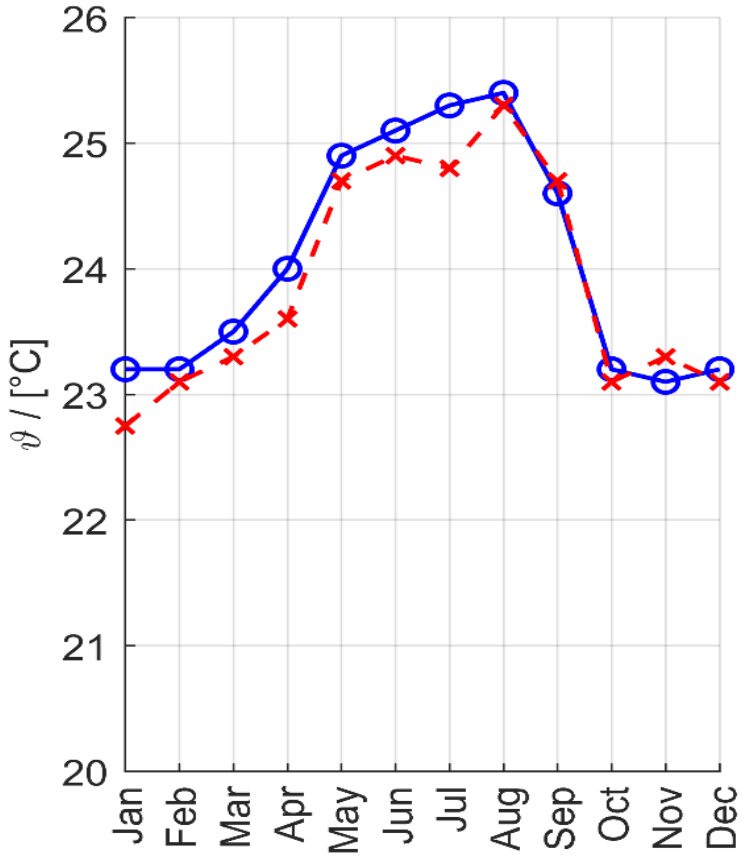
User influence – „additional window ventilation“

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Building north n_{50} [1/h]	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4
Building south n_{50} [1/h]	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5

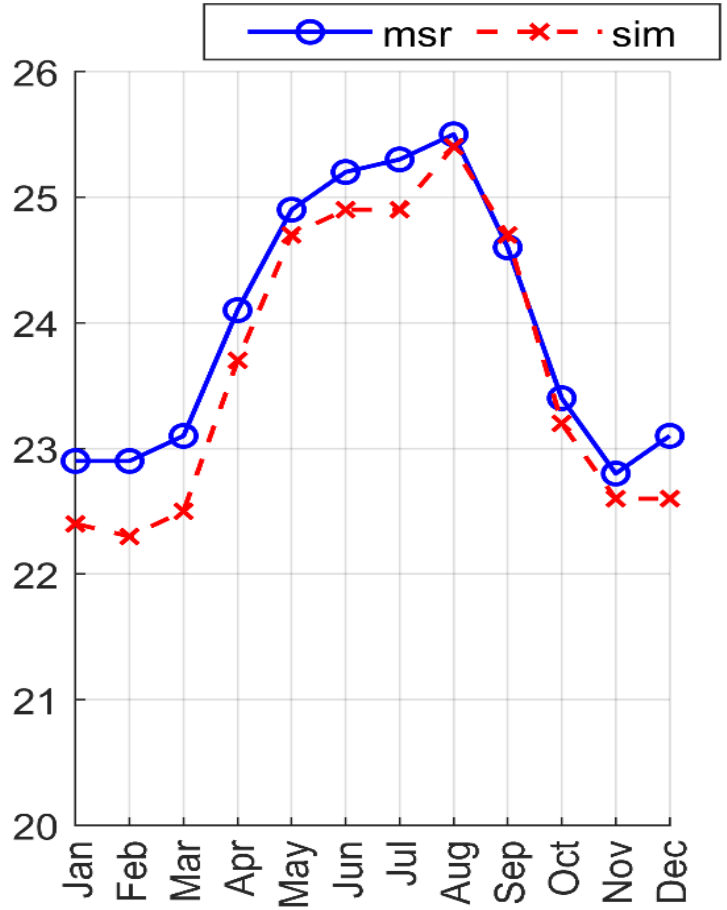




Building (CarnotUIBK) – Monthly Temperatures

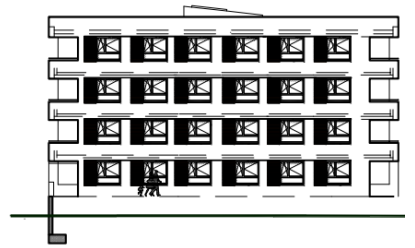


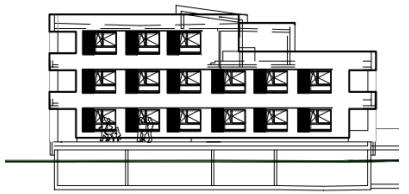
North Building



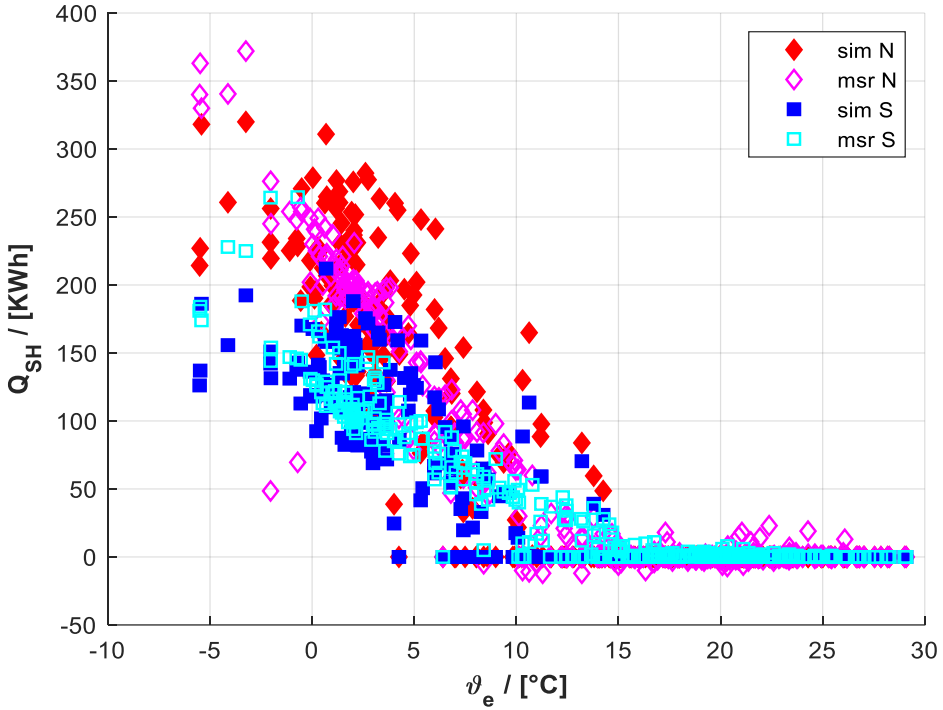
South Building

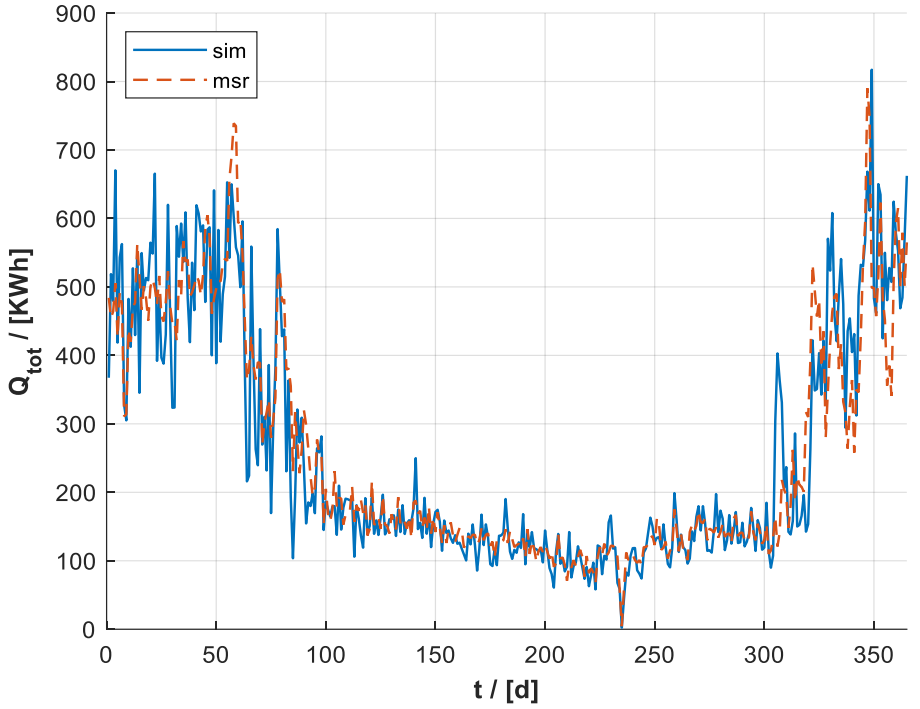
Deviation due to user Influence (time dependend)
- Presence (internal gains)
- Set point (SP)
- Window ventilation
- Shading
- other





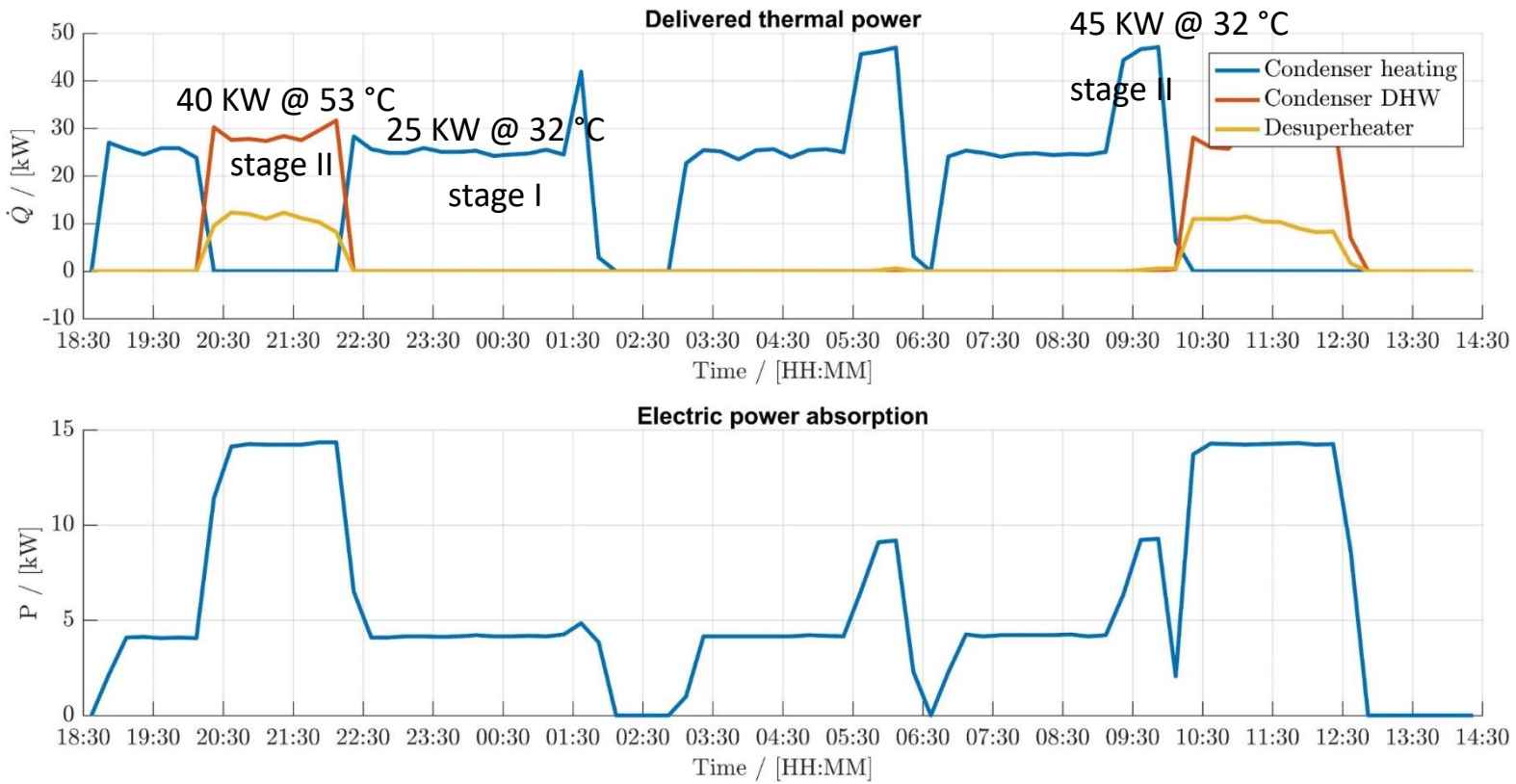
Building (CarnotUIBK) – Daily Energy Demand





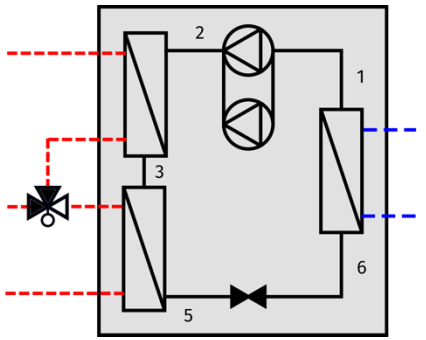
Comparison of measurement (msr) and simulation (sim);
daily SH energy demand vs. daily average ambient temperature of the North (N) and South (S) building (left) and total daily energy demand (SH + DHW) for both buildings (right)

Heat Pump



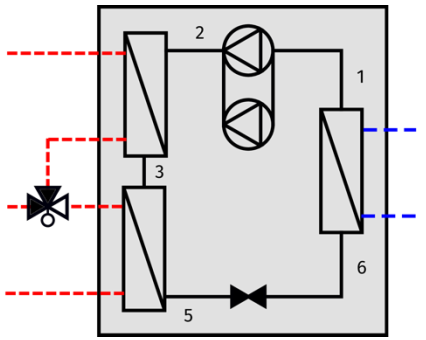
$COP_{H,I}$ = 25/4 = 6.25

$COP_{DHW,II}$ = (28+11)/14 = 2.8

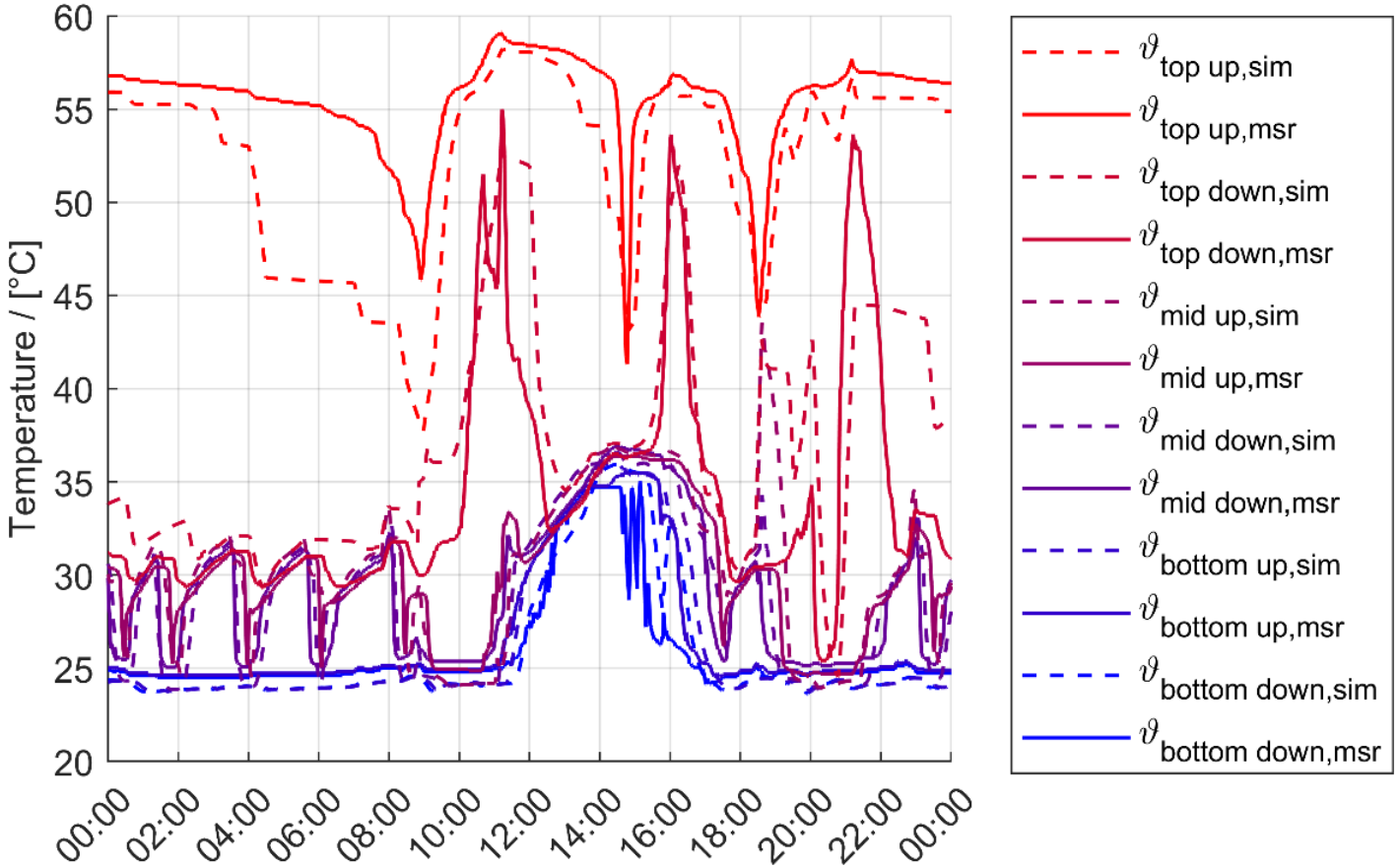


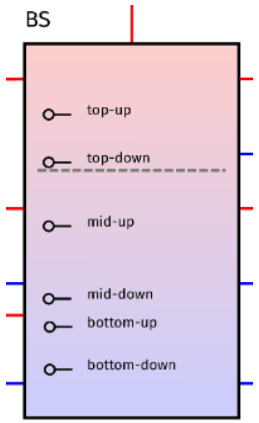
Heat Pump

- PM Model
  - Stage 1
  - Stage 2
  - DSH
- Control

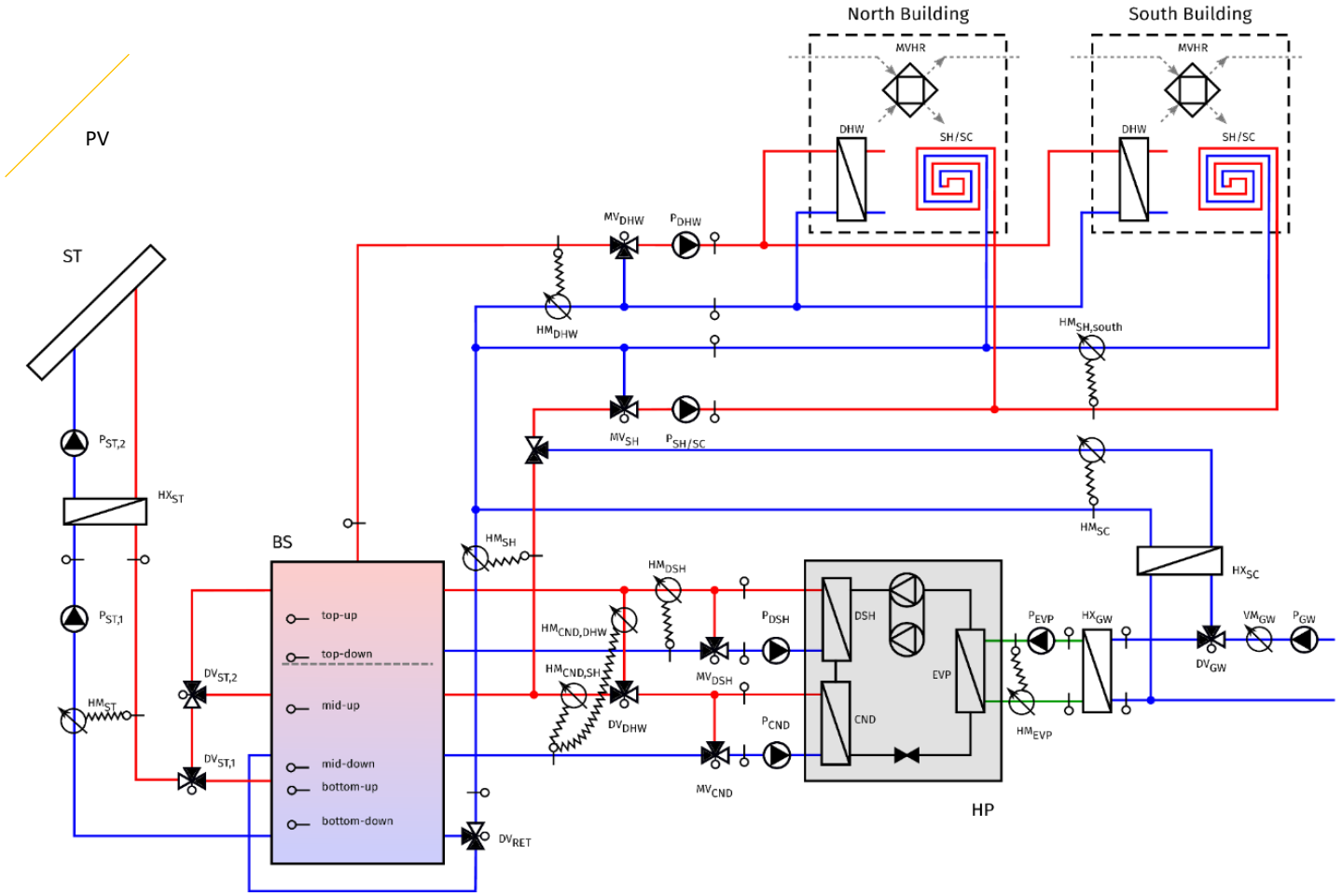


Buffer Storage

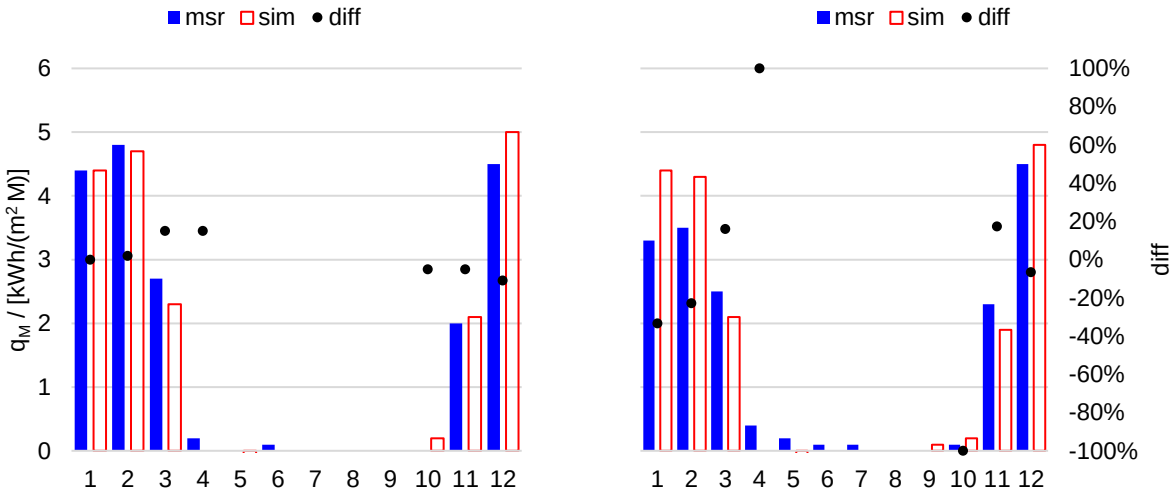


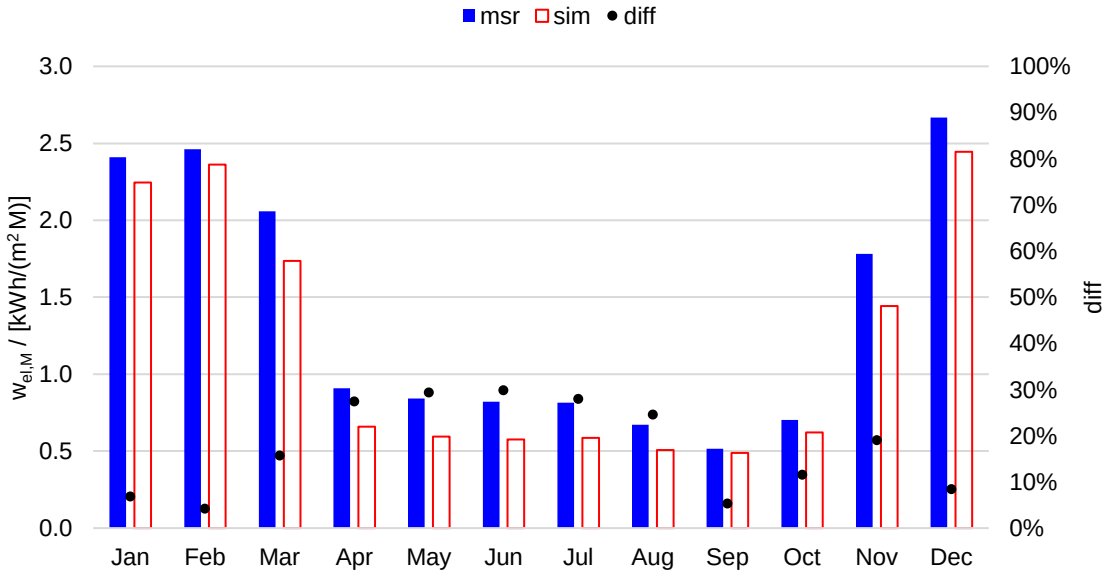


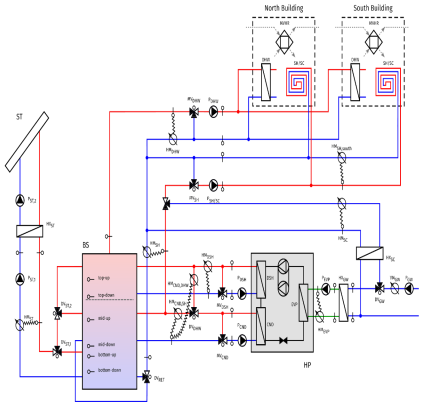
System Model



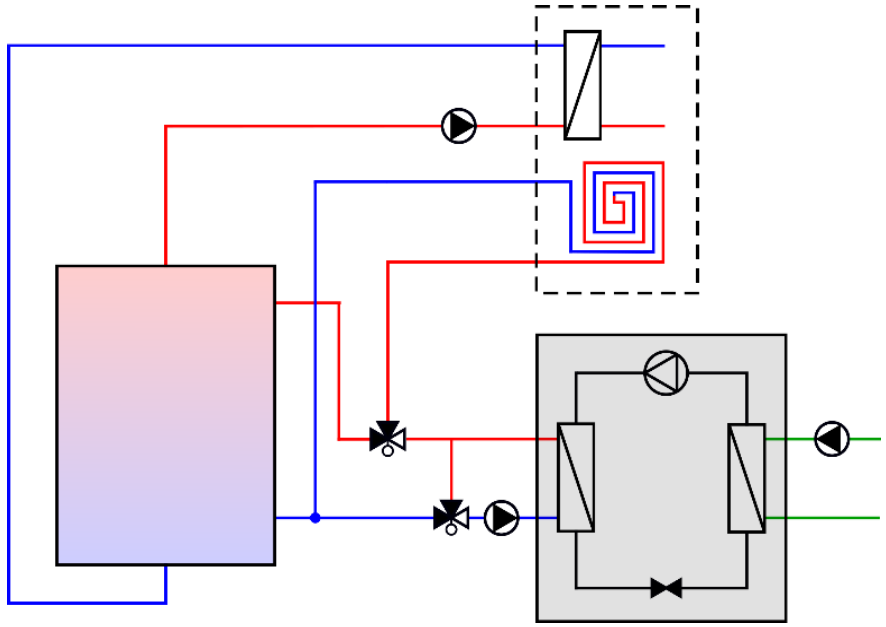
System Model



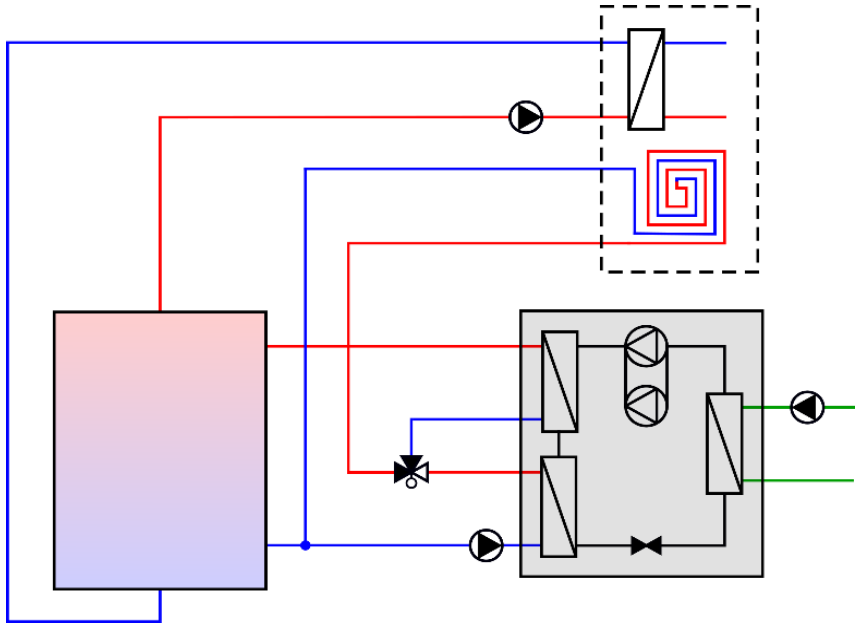




Alternative System Design

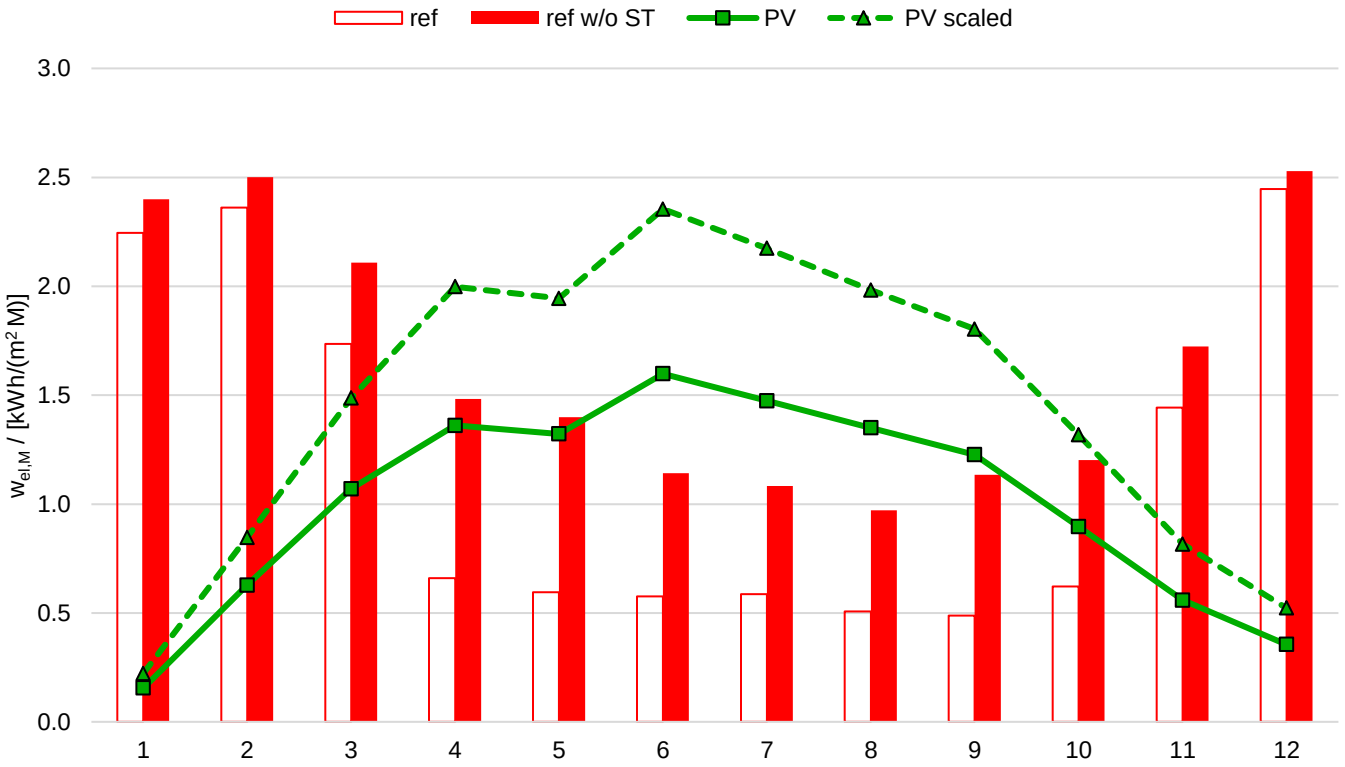


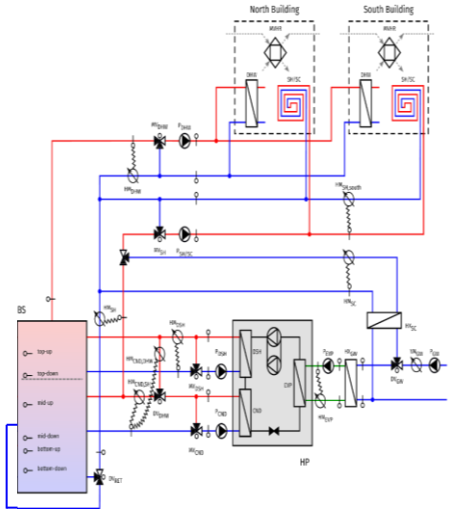
Case A “direct SH” (left) and



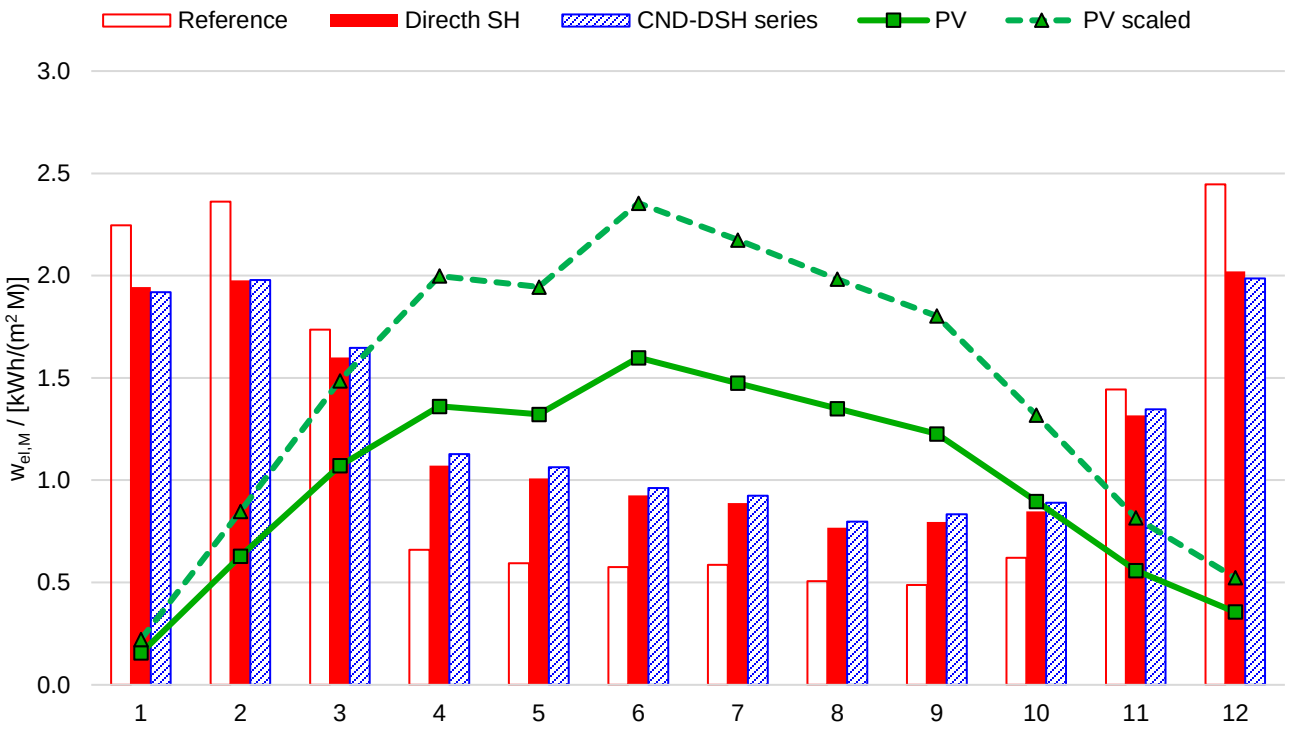
Case B “CND-DSH series connection” (right)

Alternative System Design – Solar Thermal

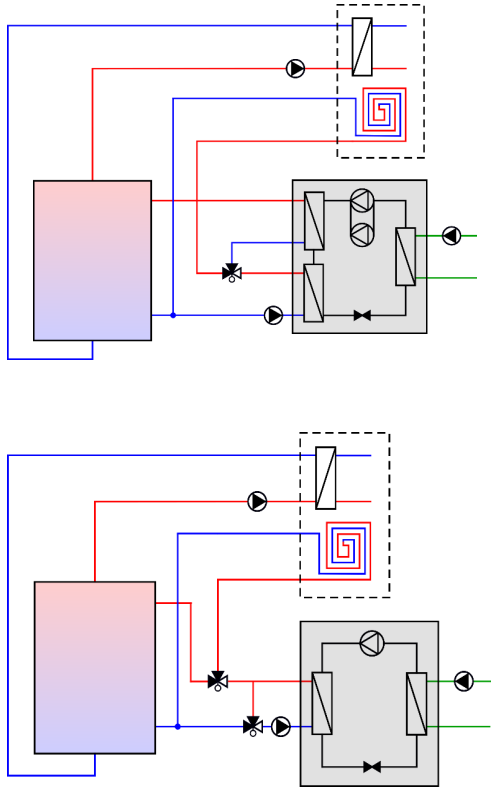




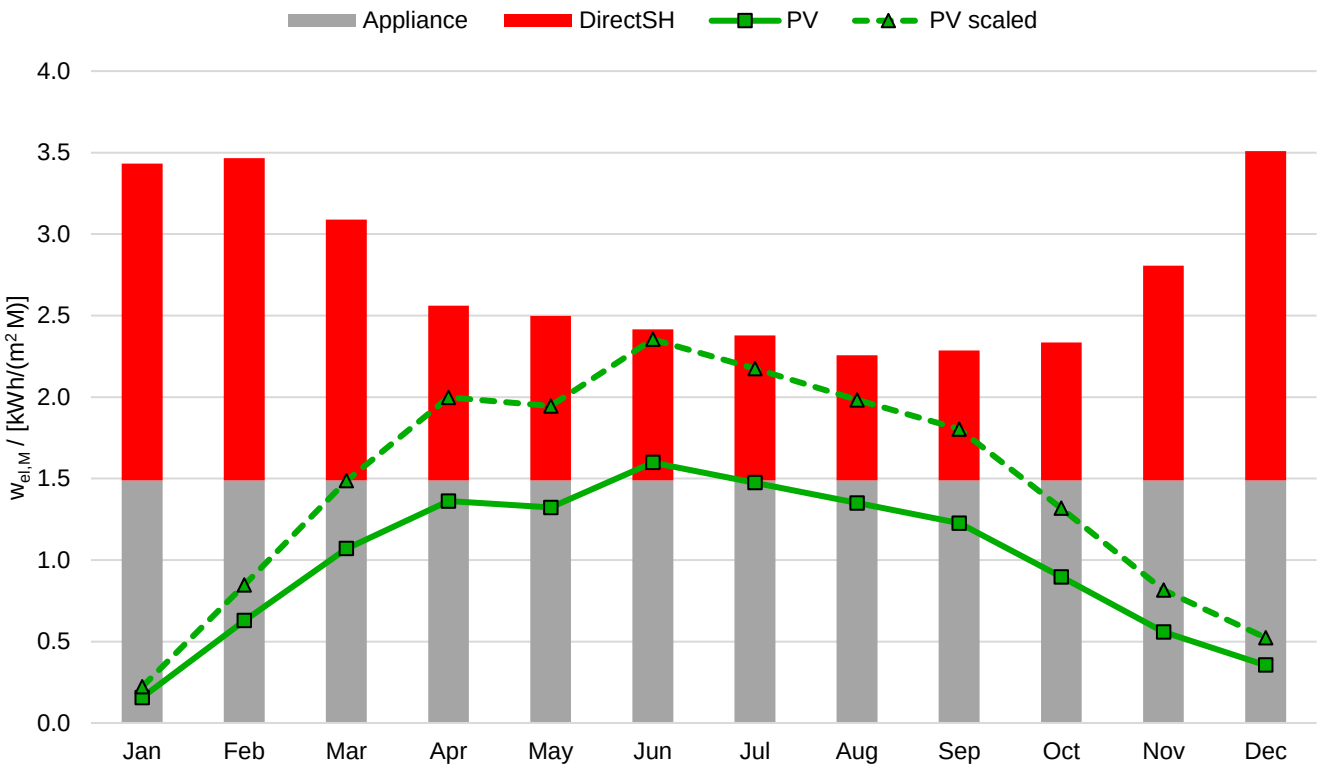
Alternative System Design – Direct SH and Desuperheater

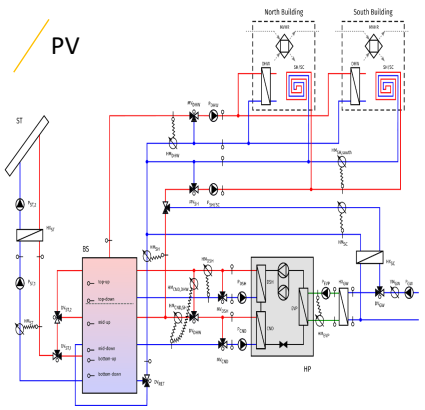


NZEB can be achieved!



Primary Energy/CO_2-Emissions and Winter Gap



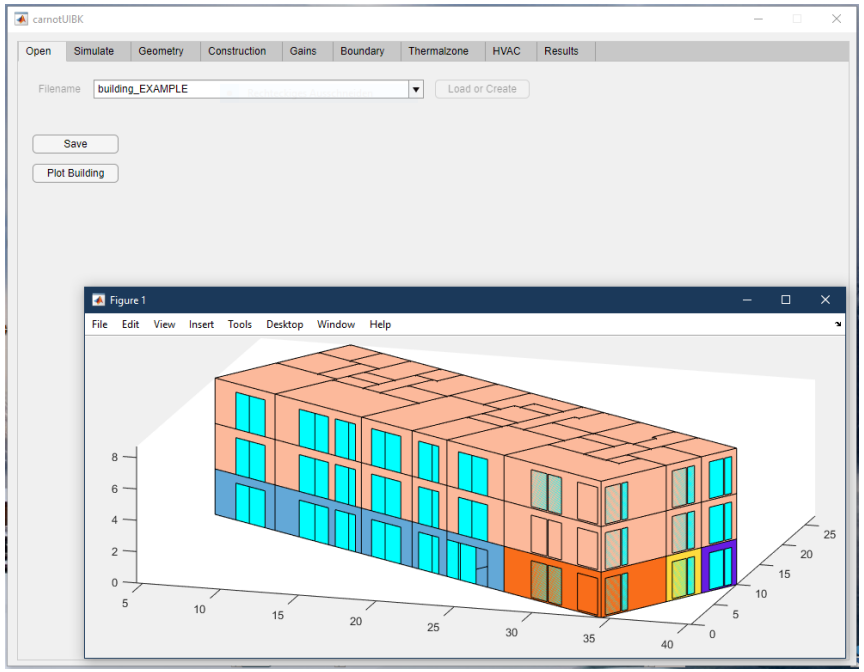


Conclusions and Outlook

- Pre-Desing, Design, Comissioning and Operation supported by Simulation
- NZEB requires optimisation on comonent and system level
- HVAC system concept with low aux!
- PV and HP overcompensates ST
- Reducing the „winter gap“ requires PH quality, optimal HP concept, and well designed and comissioned system

Features of CarnotUIBK

- Flexible Zoning (max. 10 zones)
- Different Wall Models (Resistance, R-C, and Hygrothermal)
- Different Thermal Zone Models (lumped mass, 2*, rH, CO_2)
- Multi-zone air node model
- Administration/Organisation and Documentation of Variantes
- PHPP import
- Matlab, Matlab/Simulink - Features
- Simulink: coupling with FE-Model (s-function)



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