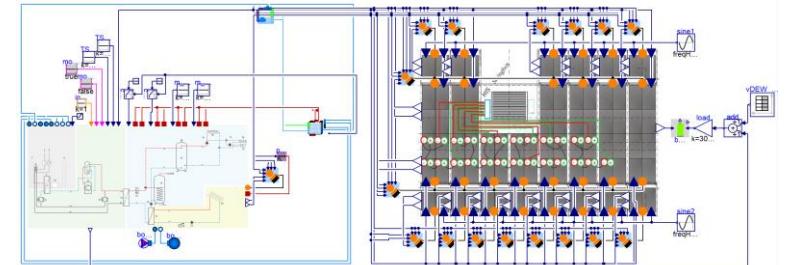


The Rooftop building and its digital twin in Modelica

Prof. Dr. Christoph Nytsch-Geusen

IBPSA Project 1 Expert Meeting, 26.-27.2.2018, Berlin



The Rooftop building @SDE 2014

Architecture Master seminar - Design project "Research station on Mars"

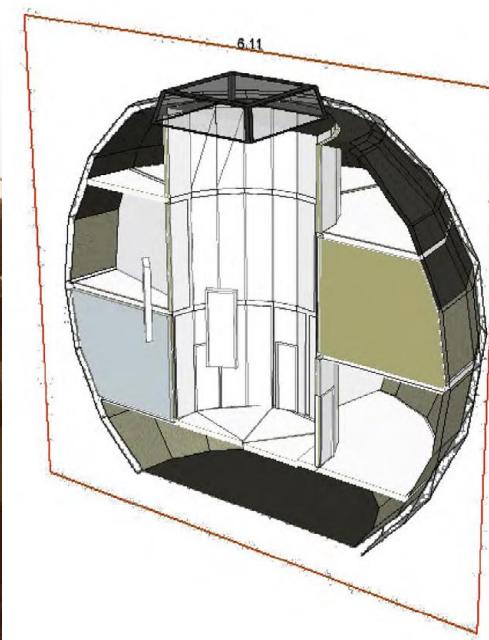
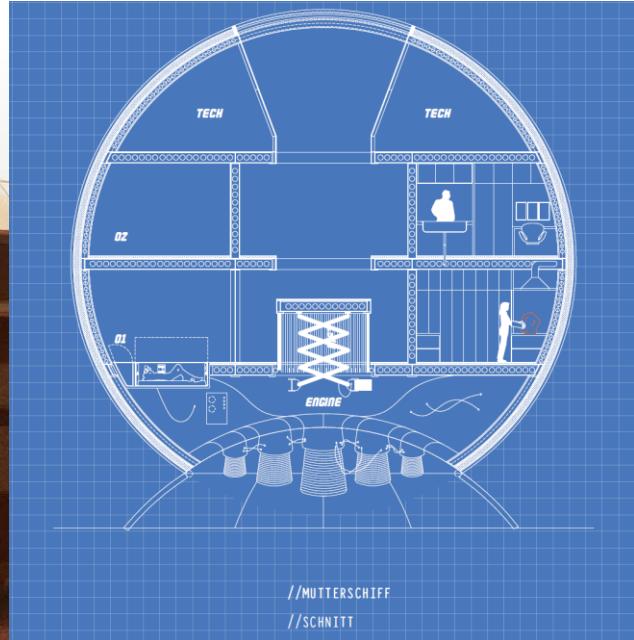
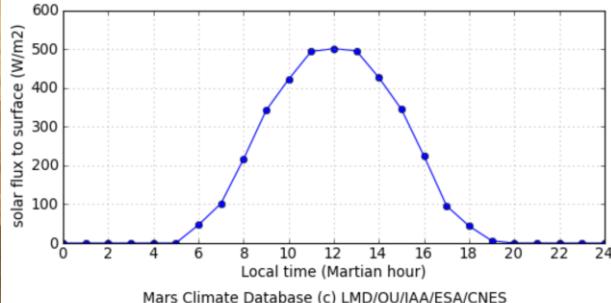
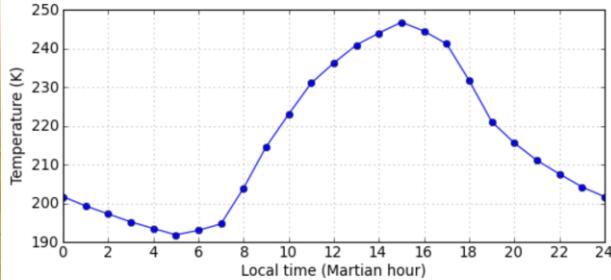
Antonie van Wyk / Can Altinsoy / Sebastian Madre / Ferdinand List (WiSe 2016 / 2017)



Architecture Master seminar - Design project "Research station on Mars"

Antonie van Wyk / Can Altinsoy / Sebastian Madre / Ferdinand List (WiSe 2016 / 2017)

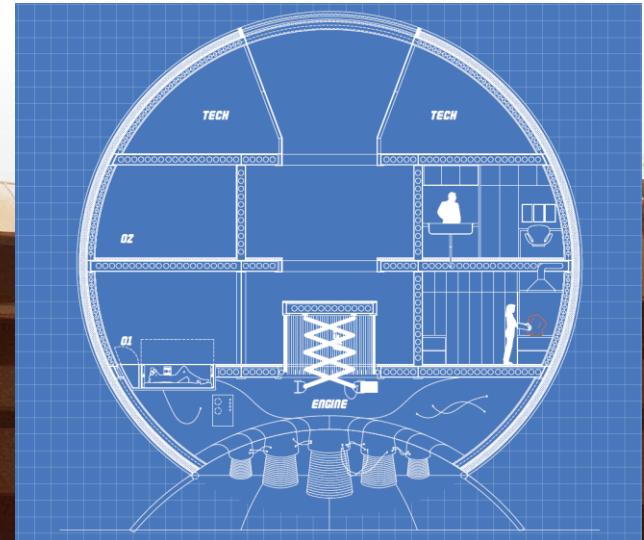
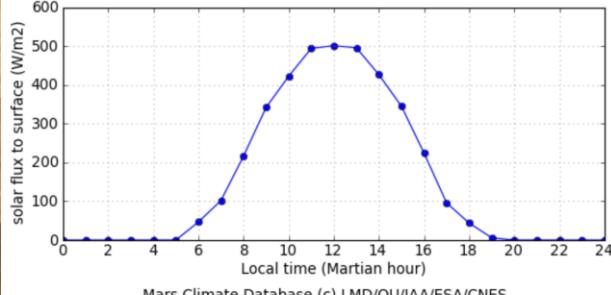
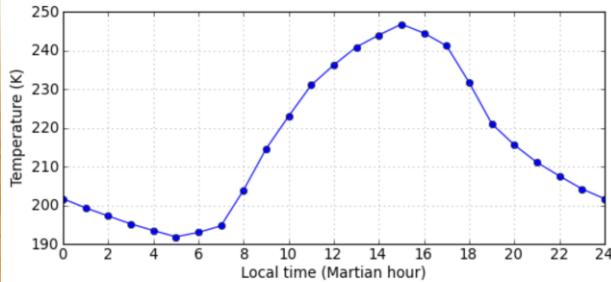
MCD v5.2 with climatology average solar scenario. Ls 150.6deg.
Latitude -4.6N Longitude 137.4E Altitude 10.0 m ALS



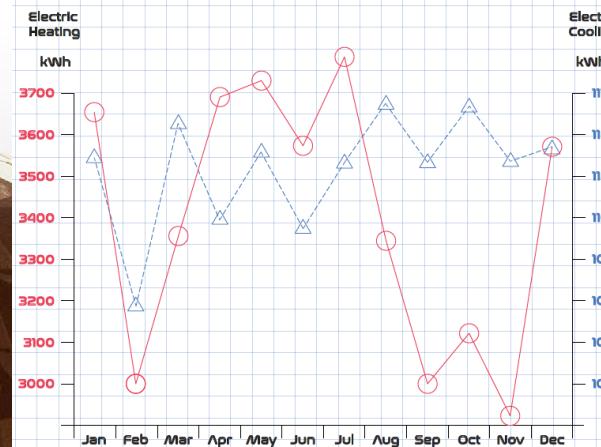
Architecture Master seminar - Design project "Research station on Mars"

Antonie van Wyk / Can Altinsoy / Sebastian Madre / Ferdinand List (WiSe 2016 / 2017)

MCD v5.2 with climatology average solar scenario. Ls 150.6deg.
Latitude -4.6N Longitude 137.4E Altitude 10.0 m ALS



1 YEAR REPORT



HEIZWÄRMEBEDARF

40.981 kWh
116,7 kWh/m²

TOTAL
103.439 kWh
294,6 kWh/m²

KÜHLENERGIEBEDARF

13.580 kWh
38,7 kWh/m²

A: 351 m²
V: 844 m³

LIGHT

2.680 kWh
7,6 kWh/m²

RATIO : 0,42

EQUIPMENT

45388 kWh
129,3 kWh/m²

Traditional learning – teacher-centred teaching



Anatomy lecture within the auditorium of the Karl-Marx University Leipzig 1981 (Source: Wikipedia)

Learning within an interdisciplinary project group



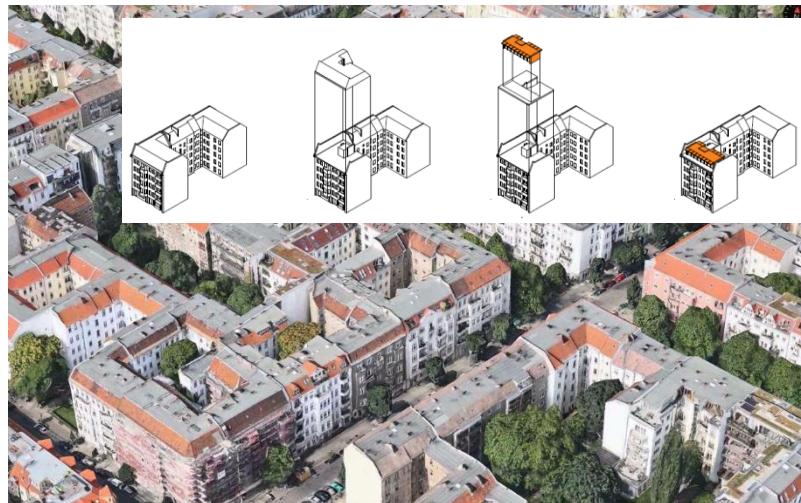
Team Rooftop (SDE 2014): 40 students of UdK Berlin and TU Berlin

Source: Team Rooftop

From the idea to the solar building – Planning phase



Team Rooftop



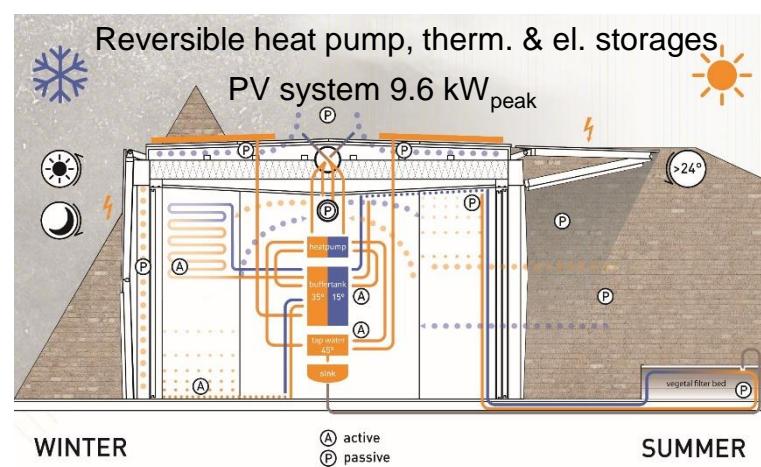
Concept of urban planning



Integration in the building stock



Design process



Energy concept and technical detailed planning



Source: Team Rooftop

From the idea to the solar building – Realization phase

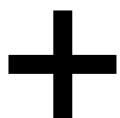


Money (SDE 2014, BMWi),
Product sponsoring by industry

Support by UdK Berlin and TU Berlin as well
as vocational school OSZ



Transport Berlin → Versailles

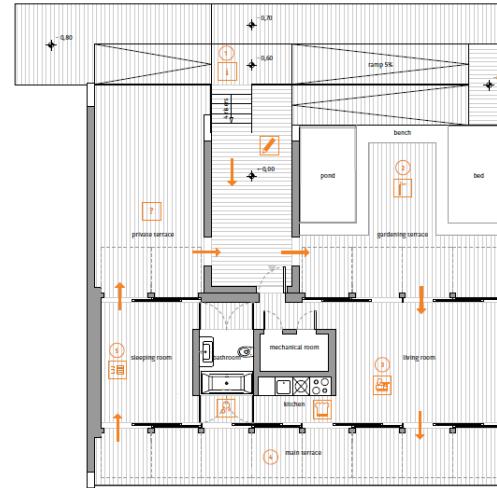


Re-assembling in a triple-shift operation within 10 days

Rooftop building at SDE 2014 – South and nord facade



South facade (Source: UdK Berlin)



Visitors tour at SDE 2014 (Source: Team Rooftop)



North facade (Source: Team Rooftop)

Rooftop building – South facade during opening process



Source: Team Rooftop

Solar Decathlon Europe 2014 – 20 teams – 600 students



Participating student teams of the Solar Decathlon Europe 2014 on the competition area in Versailles (Source: SDE 2014)

ATC / Atlantic Challenge: Phileas Nantes, France.	BAR: Ressò Barcelona, Spain.	BUC: EFdeN Bucarest, Romania.	CUJ: Renai House Chiba, Japan.
DEL / Prêt-à-Loger: Home with a Skin Delft, Netherlands.	DTU: Embrace Copenhagen, Denmark.	FNX: Team & Casa Fenix Valparaiso, Chile / La Rochelle, France.	INS / Inside Out: Techstyle Haus Providence, U.S.A. / Erfurt, Germany.
KMU / Kmutt Team: Adaptive House Bangkok, Thailand.	LUC / Lucerne Team: your+ Lucerne, Switzerland.	MEX / Team Mexico UNAM: Casa Mexico City, Mexico.	OTP: OnTop Frankfurt, Germany.
PAR / Team Paris: Liv-Lib' Paris, France.	PLT / Plateau Team: Symbicity Alcala & La Mancha, Spain.	REC / Team Réciprocé: Maison Reciprocity Boone, U.S.A. / Angers, France.	ROF / Team Rooftop: Rooftop House Berlin, Germany.
TEC: Tropika Cartago, Costa Rica.	UNI / Team Unicode: Orchid House Hsinchu, Taiwan.	ROME / Team Rhome: Rhome for Dencity Rome, Italy.	SHU / Team Shunya: H° Mumbai, India.

Final placement Team Rooftop

4th Place Overall Assessment
3rd Place Architecture



Award ceremony SDE 2014 (Source: Team Rooftop)

LIVE MONITORING & SCORING

RANK	PROJECT	COUNTRY	SCORE
1	RHOME FOR DENCITY	DE	840.63
2	PHILÉAS	FR	839.75
3	HOME WITH A SKIN	NL	837.87
4	ROOFTOP	DE	823.42
5	YOUR+	CH	804.75
6	CASA FENIX	PT	802.42
7	ONTOP	DE	793.71
8	EMBRACE	NO	780.01
9	MAISON RECIPROCITY	FR	776.92
10	RESSÒ	ES	776.24
11	RENAHOUSE	PL	774.09
12	ORCHID HOUSE	TW	772.15
13	CASA	PT	760.17
14	TECHSTYLE HAUS	DE	657.46
15	SYMCITY	ES	650.44
16	TROPIKA	PT	588.8
17	ADAPTIVE HOUSE	NL	508.15
18	H NAUGHT	GR	452.3
19	EFDEN	BE	348.49
20	LIV-LIB	DE	268.81

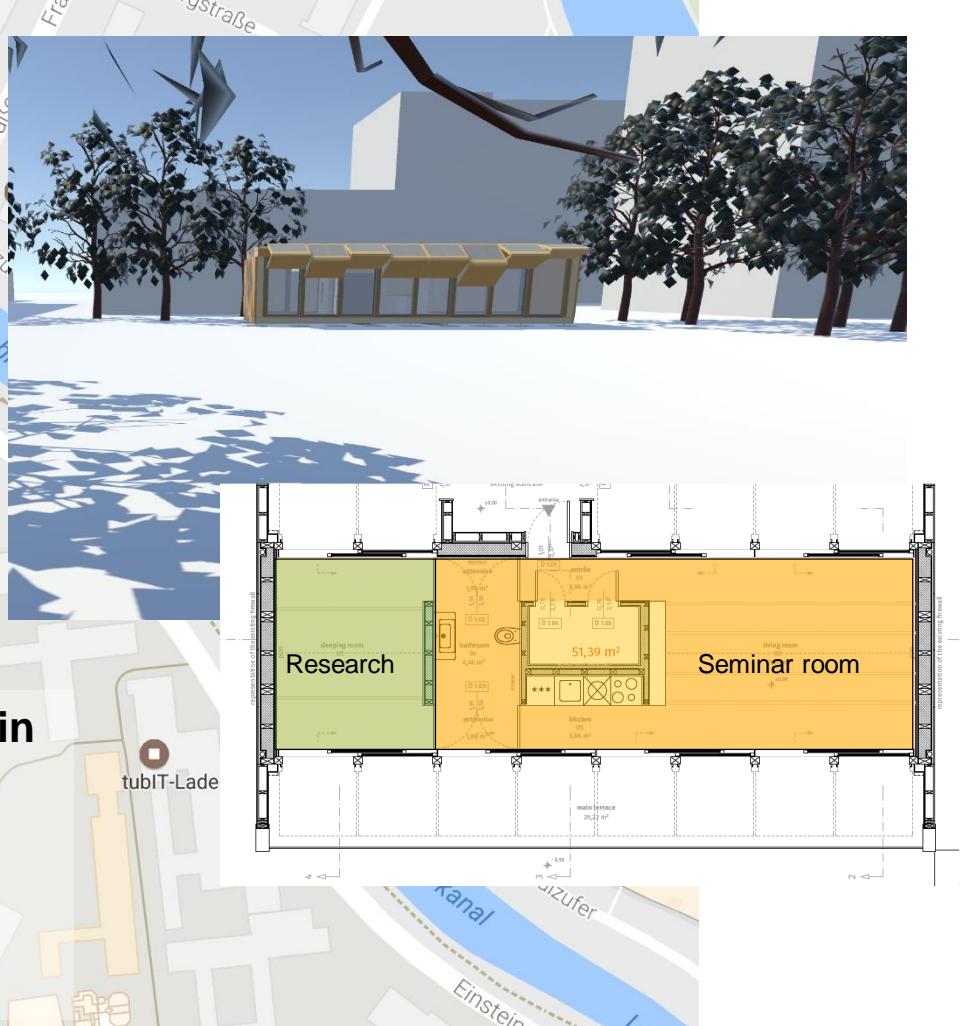
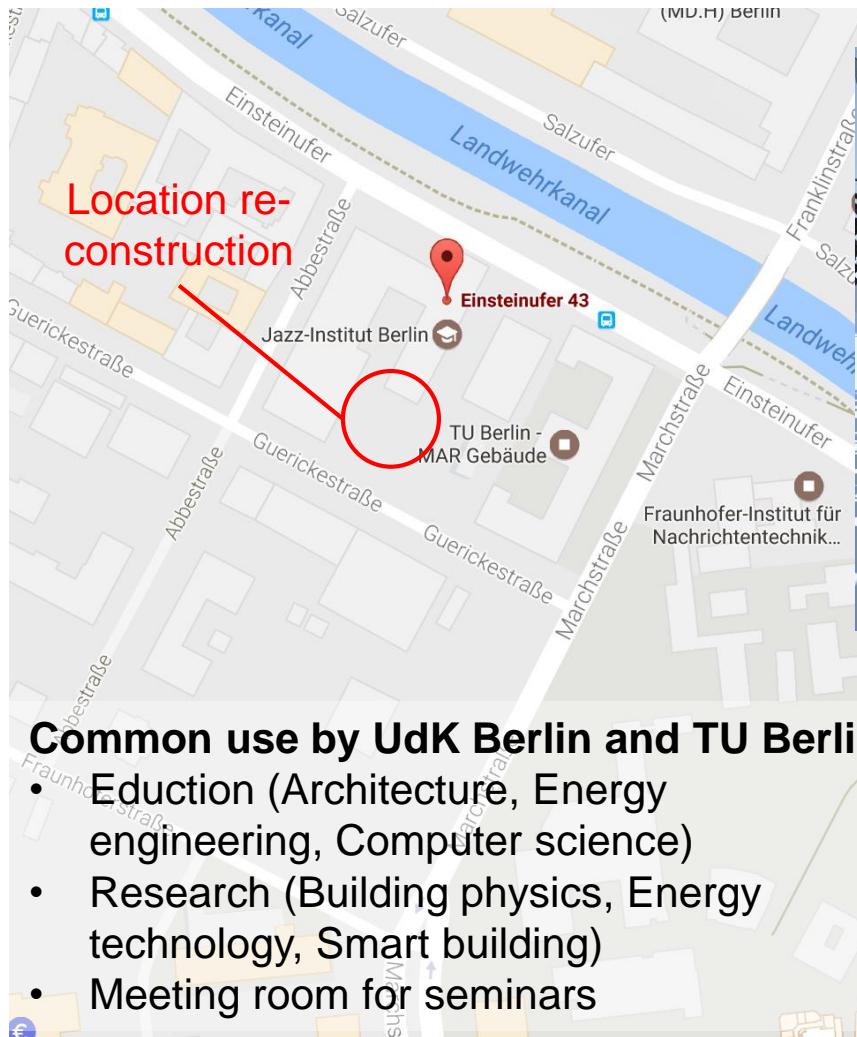
The future use of the Rooftop building

Re-construction on the University Campus Berlin-Charlottenburg



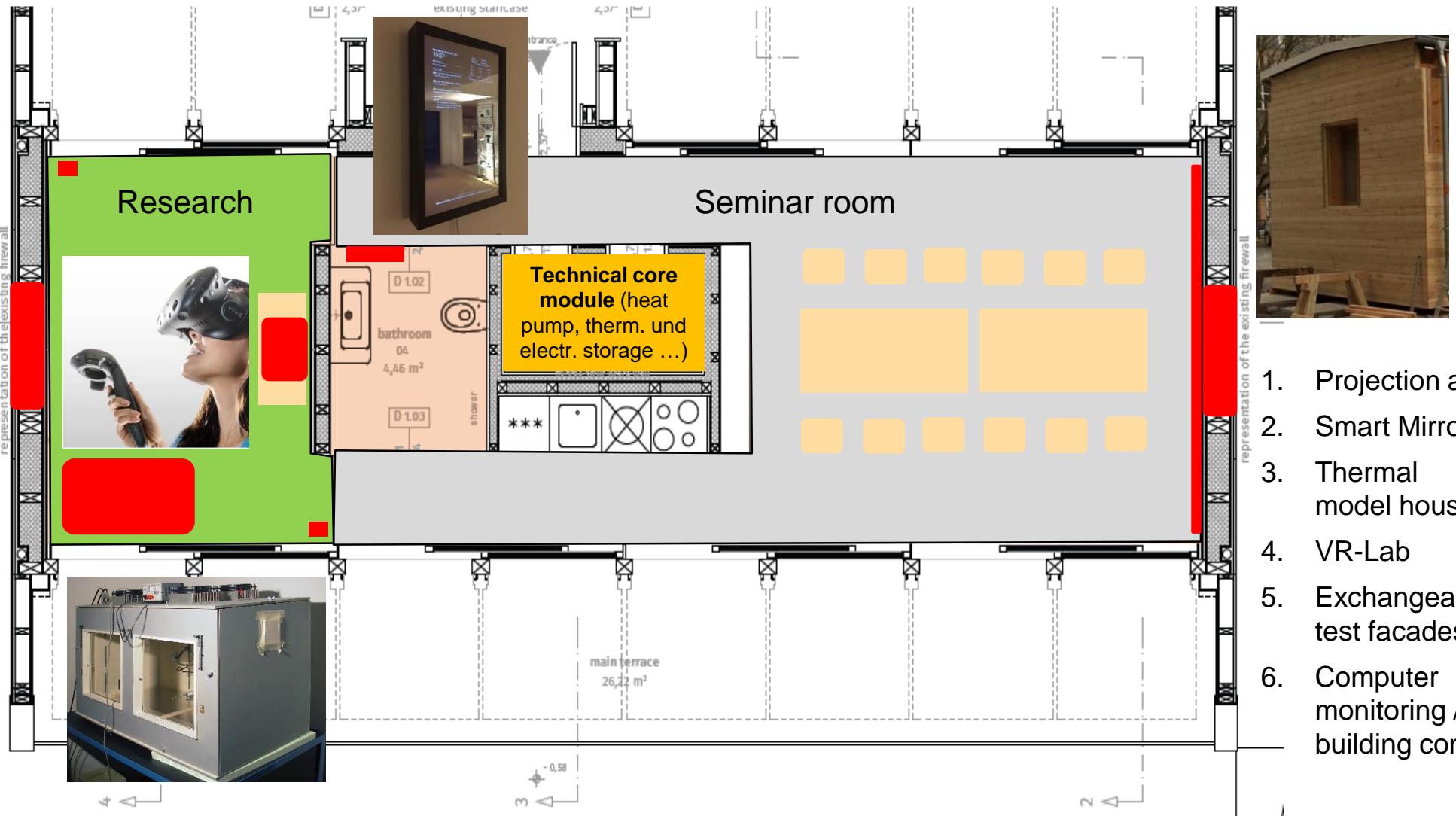
Re-construction of the Rooftop building since February 2017 (Source: UdK Berlin)

Future use on the University Campus Berlin-Charlottenburg



Sources: Google Maps, UdK Berlin

Equipment of the Rooftop building for the future use

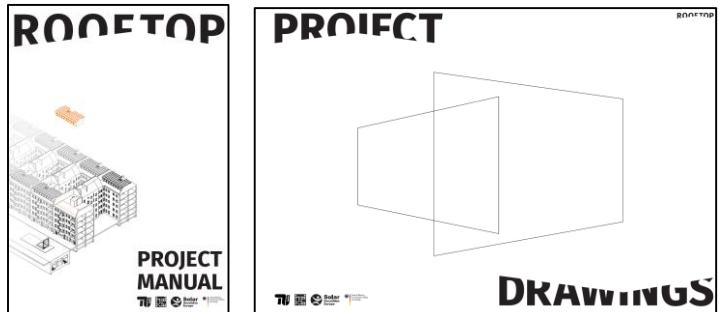


Rooftop building's digital twin in Modelica

Motivation for a digital twin

– Small (55 m² useful area) and flexible building

- 4 thermal zones
- Climate adaptable building envelope (day and night, summer and winter)



– Very detailed documentation available

- 1,000 pages project description
- 250 pages construction drawings
- BIM model (ArchiCad, IFC)

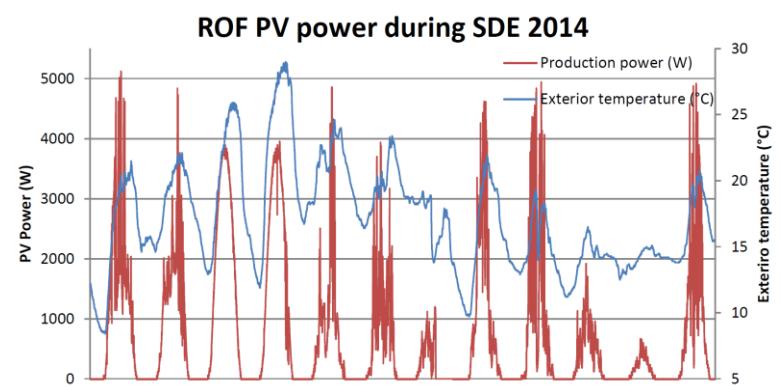


– Interesting bandwidth of building technology

- PV, heat pump, battery, adaptable façade ...

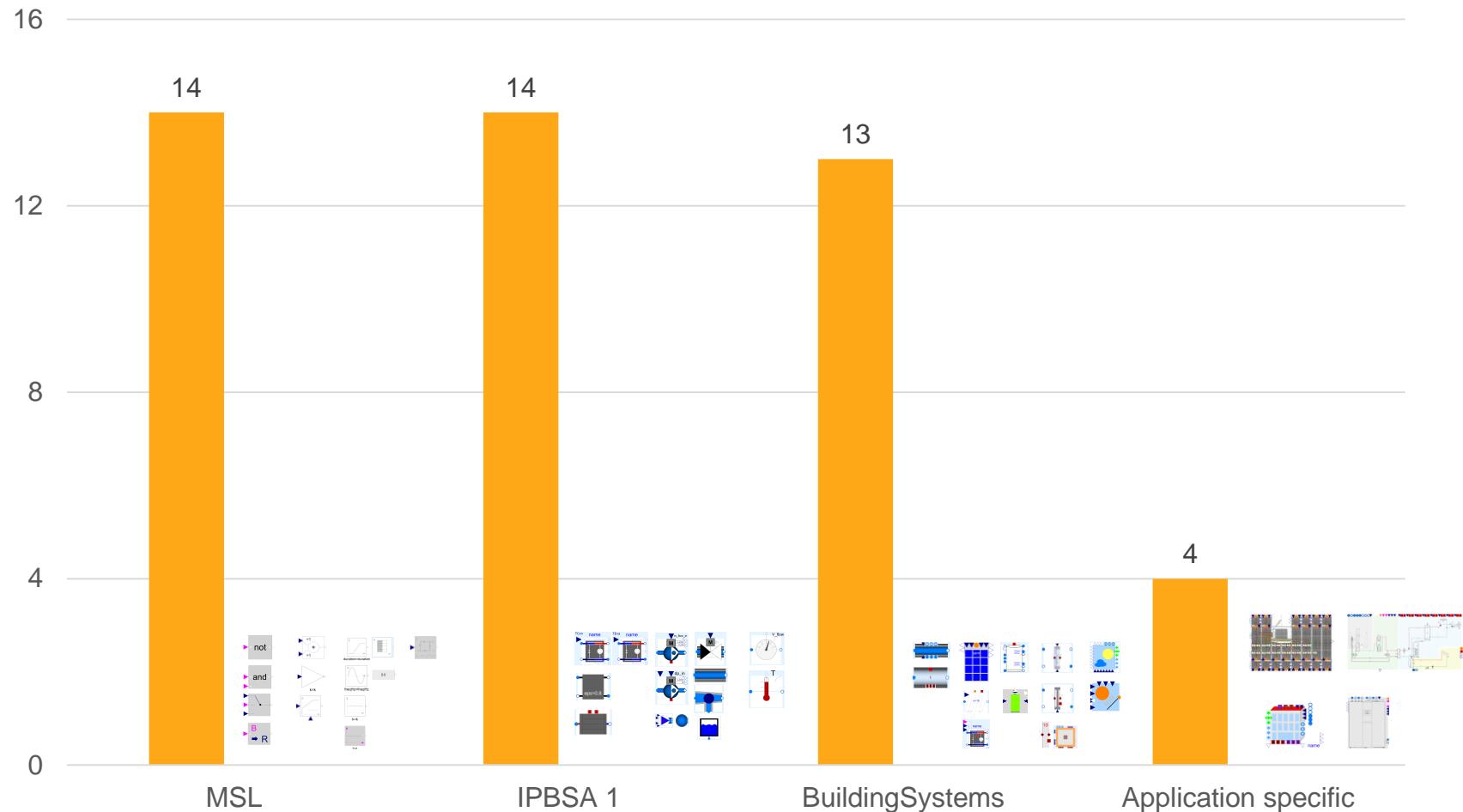
– Real operation

- Monitoring (outdoor / indoor climate, HVAC, PV)
- Testbed for control strategies / algorithms

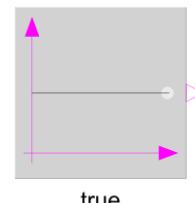
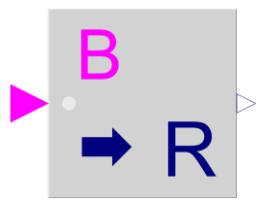
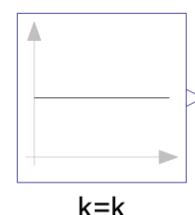
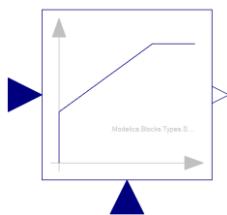
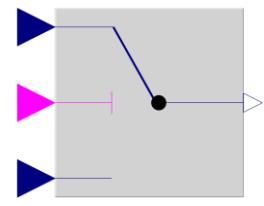
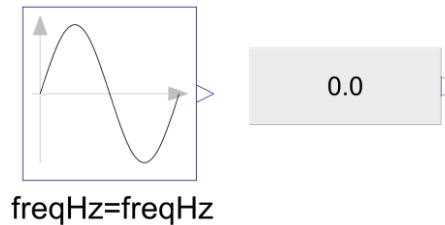
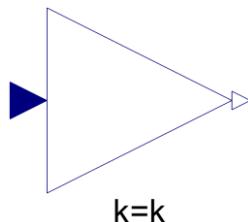
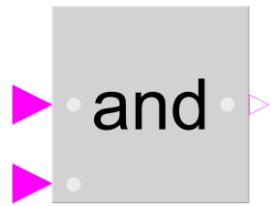
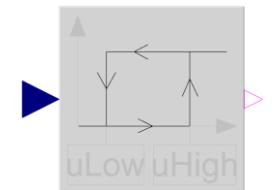
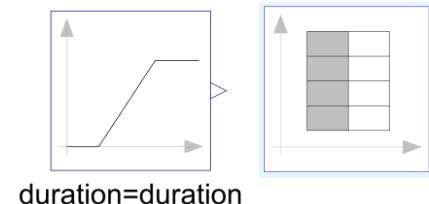
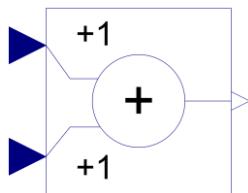
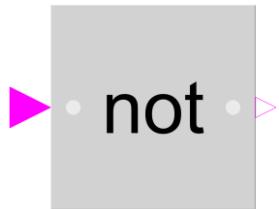


Modelling base

45 different used model classes



Models from Modelica standard library



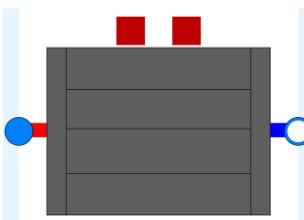
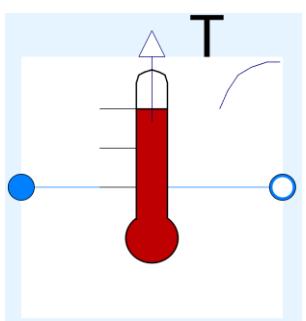
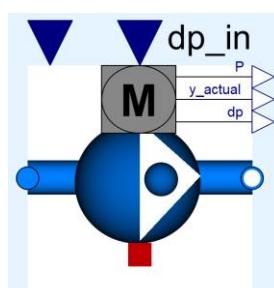
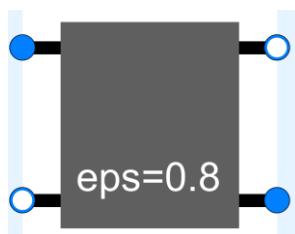
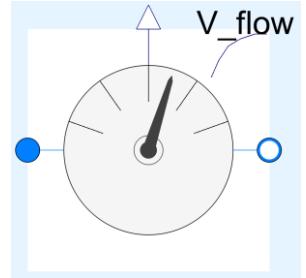
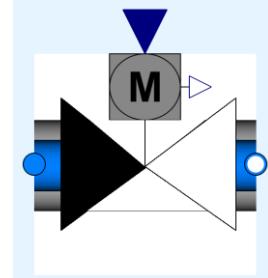
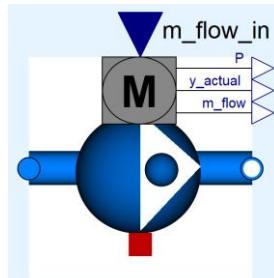
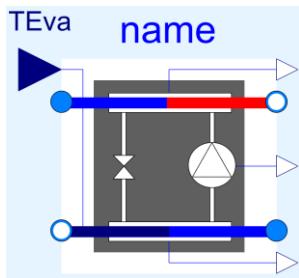
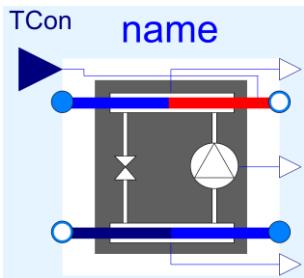
Logic, routing

Math

Sources

Control

Models from IBPSA Project1 library

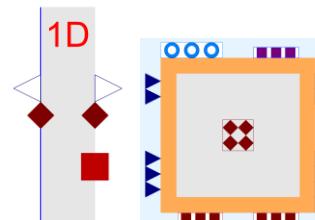
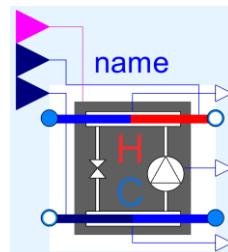
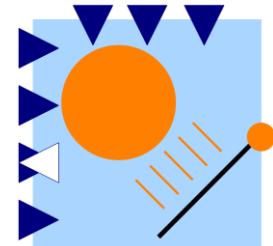
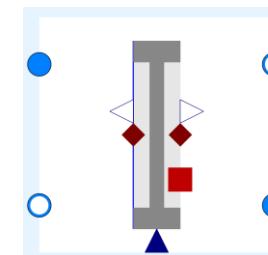
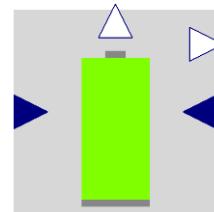
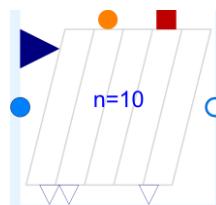
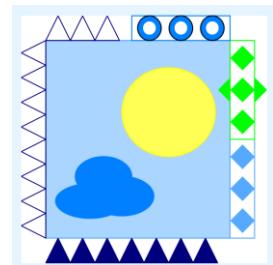
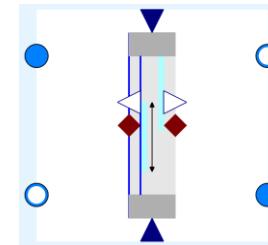
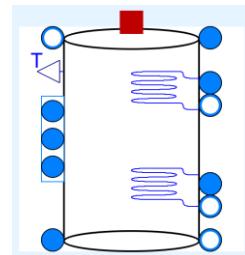
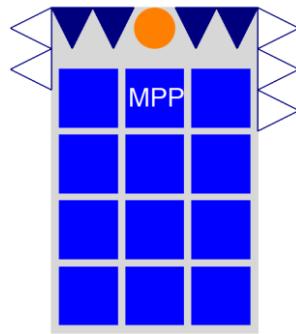
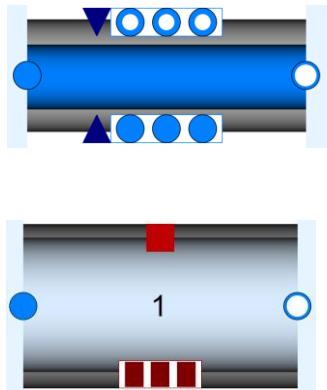


Energy transformers and heat exchangers

Hydraulic components

Sensors

Models from BuildingSystems library



Hydraulic
components

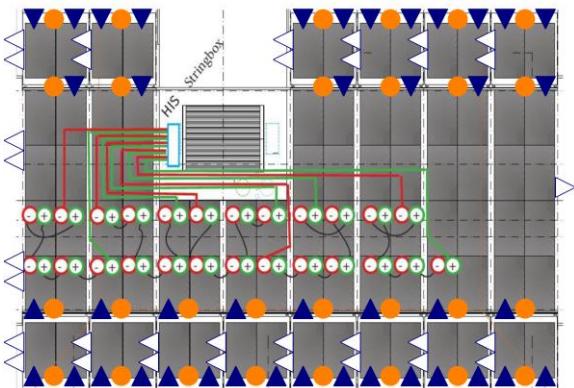
Energy
transformers

Energy
storages

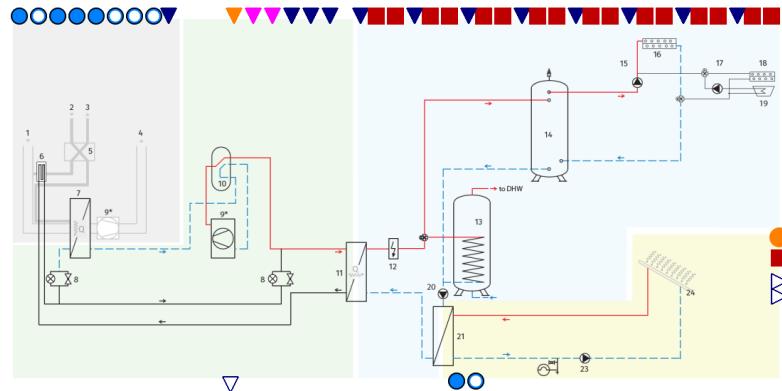
Building
components

Weather
components

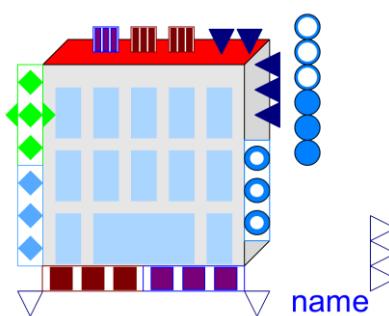
Project specific models



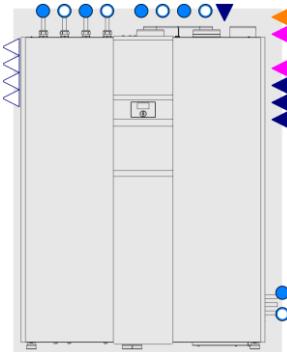
Photovoltaic sub-system



HVAC sub-system



Multi-zone building

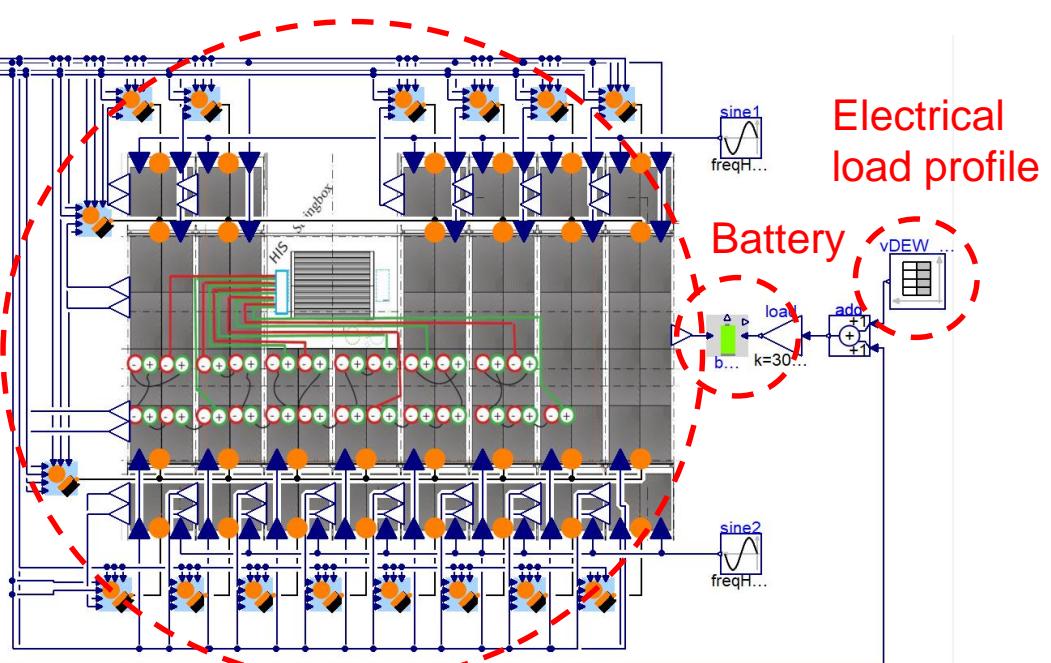
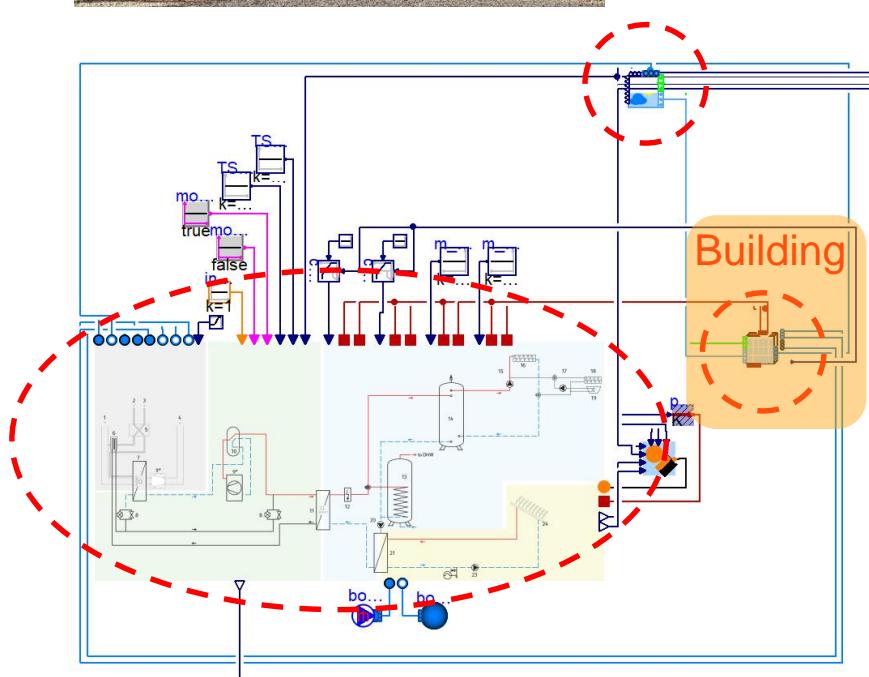


Vendor specific heat pump

Modelica model of the Rooftop building – System level

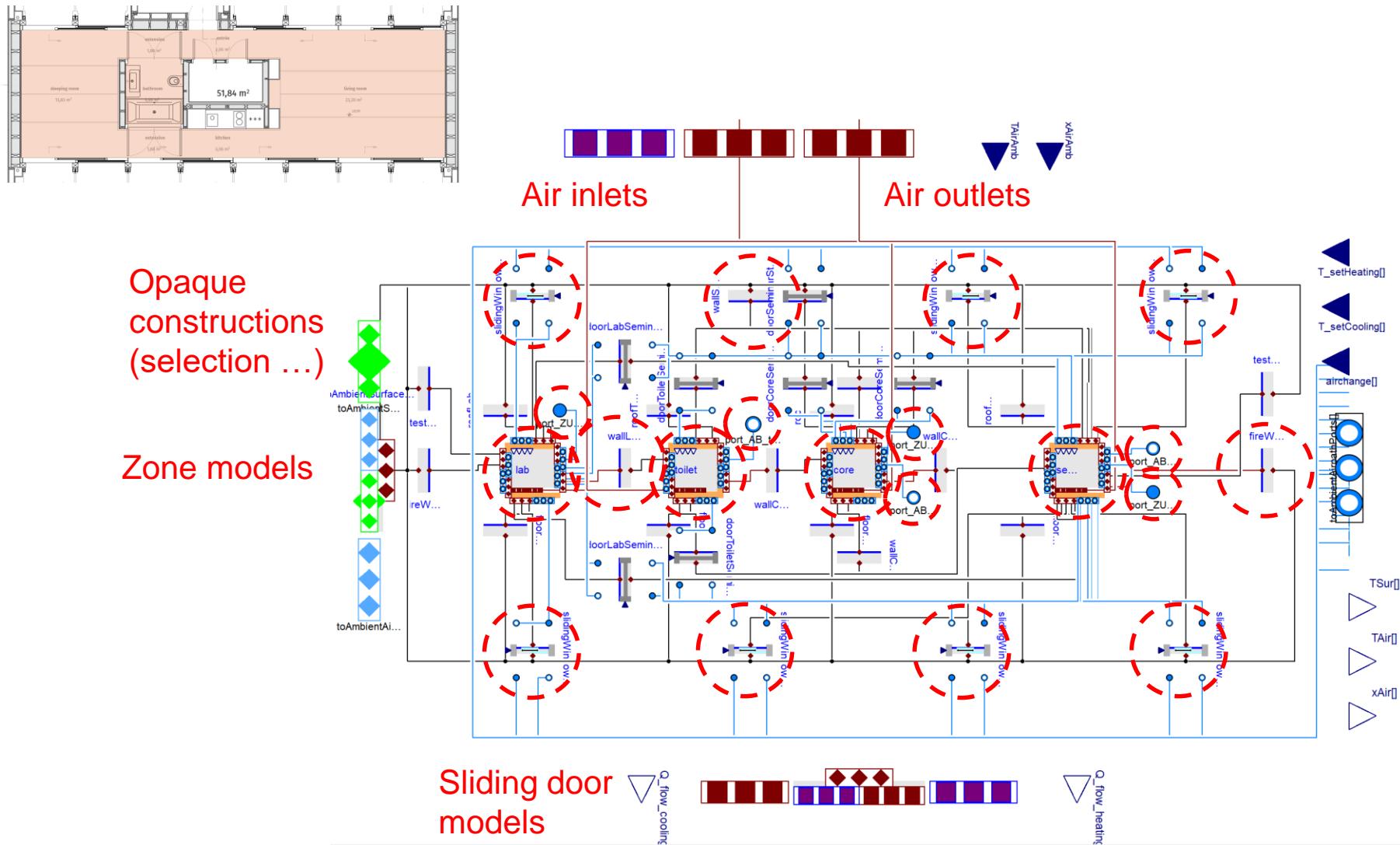


Climate

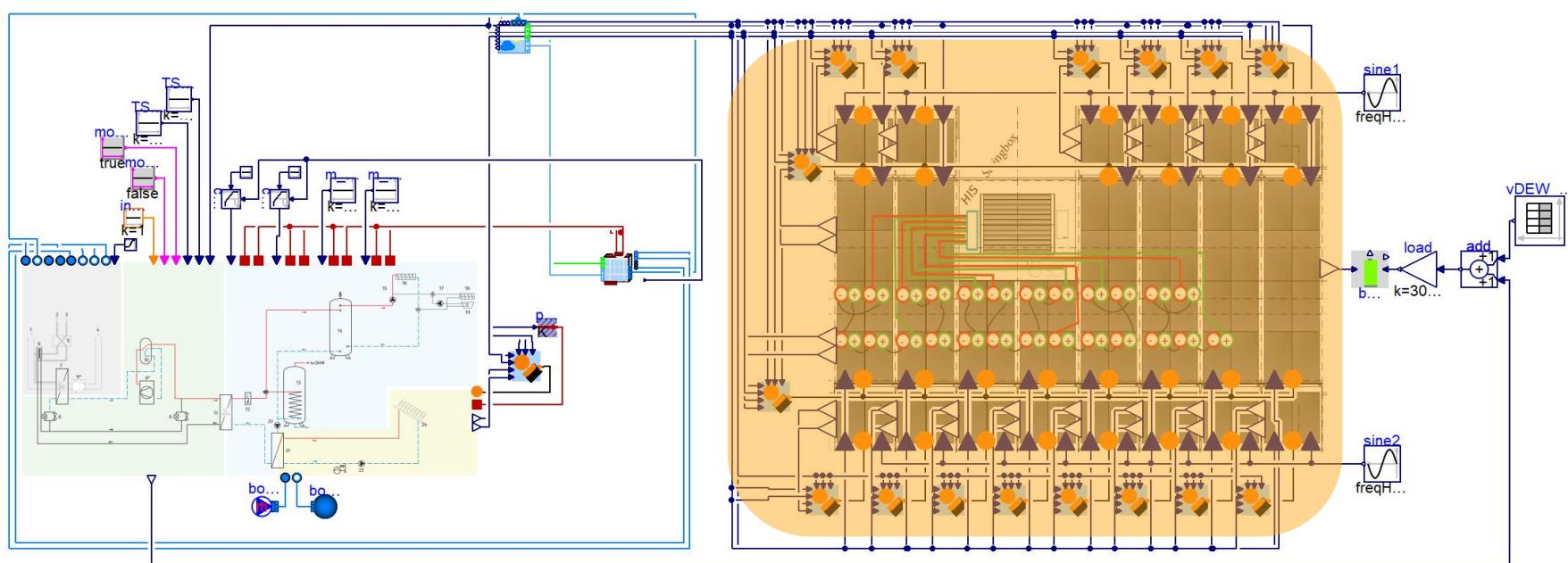
Electrical
load profile

Battery

Modelica model of the Rooftop building – Building model



Modelica model of the Rooftop building – System level



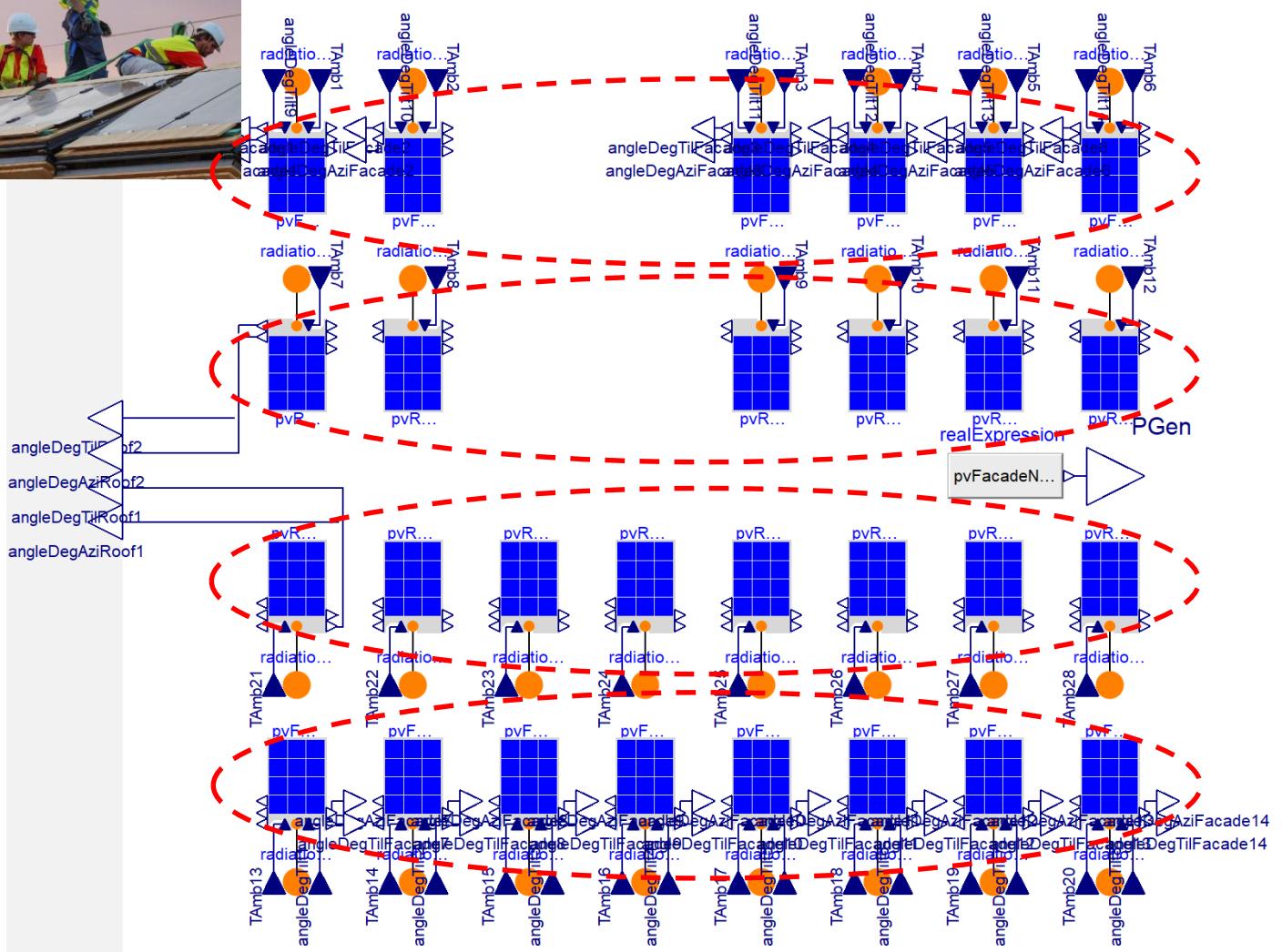
PV system

Modelica model of the Rooftop building – PV system

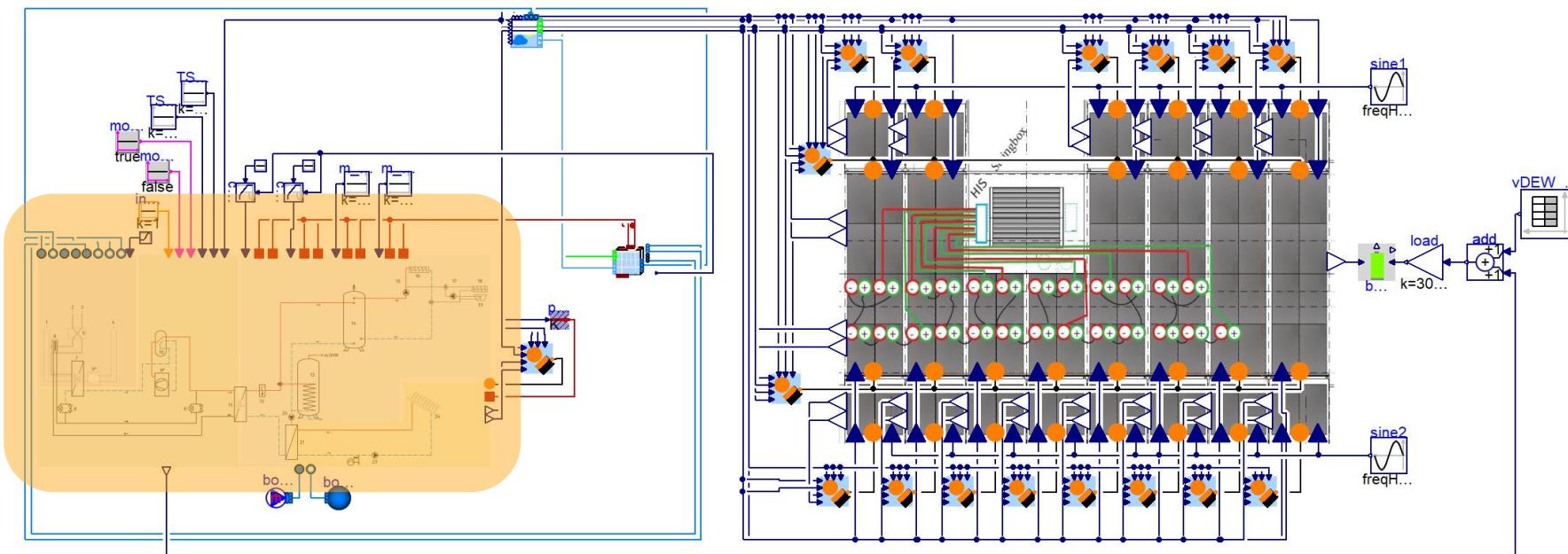


Fixed PV modules

One-axis tracked
PV modules

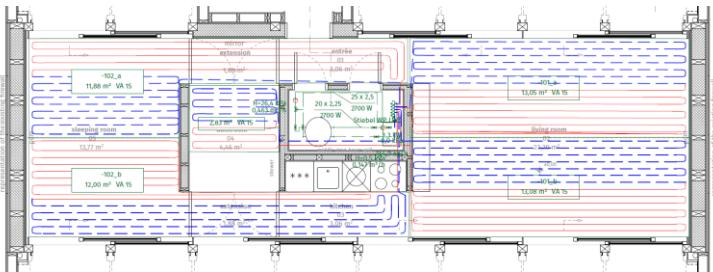


Modelica model of the Rooftop building – System level

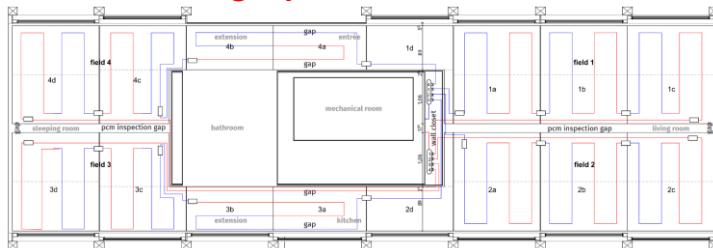


HVAC system

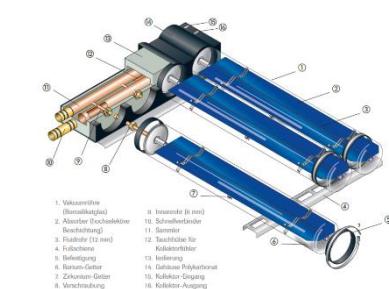
Modelica model of the Rooftop building – HVAC system



Floor heating system



Cooling ceiling system



Solar thermal system

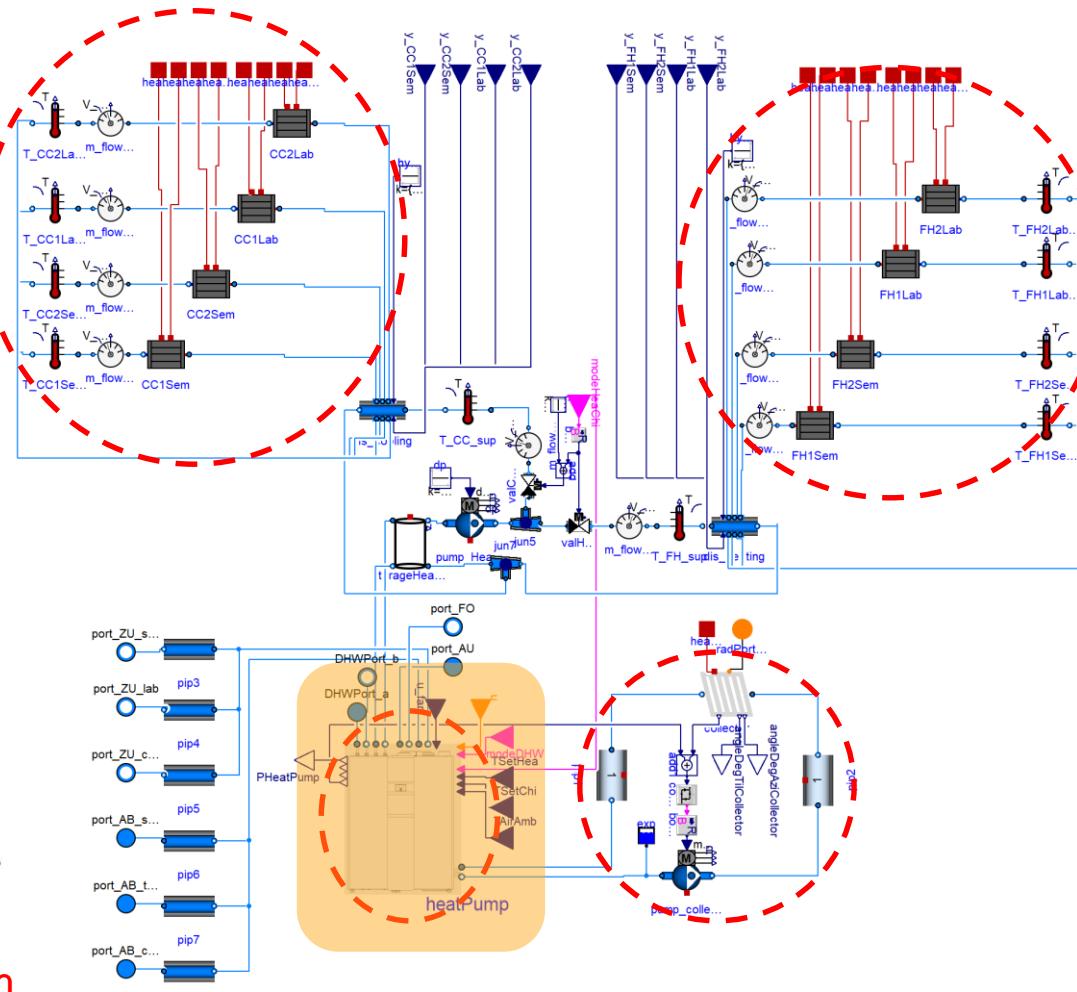
Heat pump LWZ 304 SOL



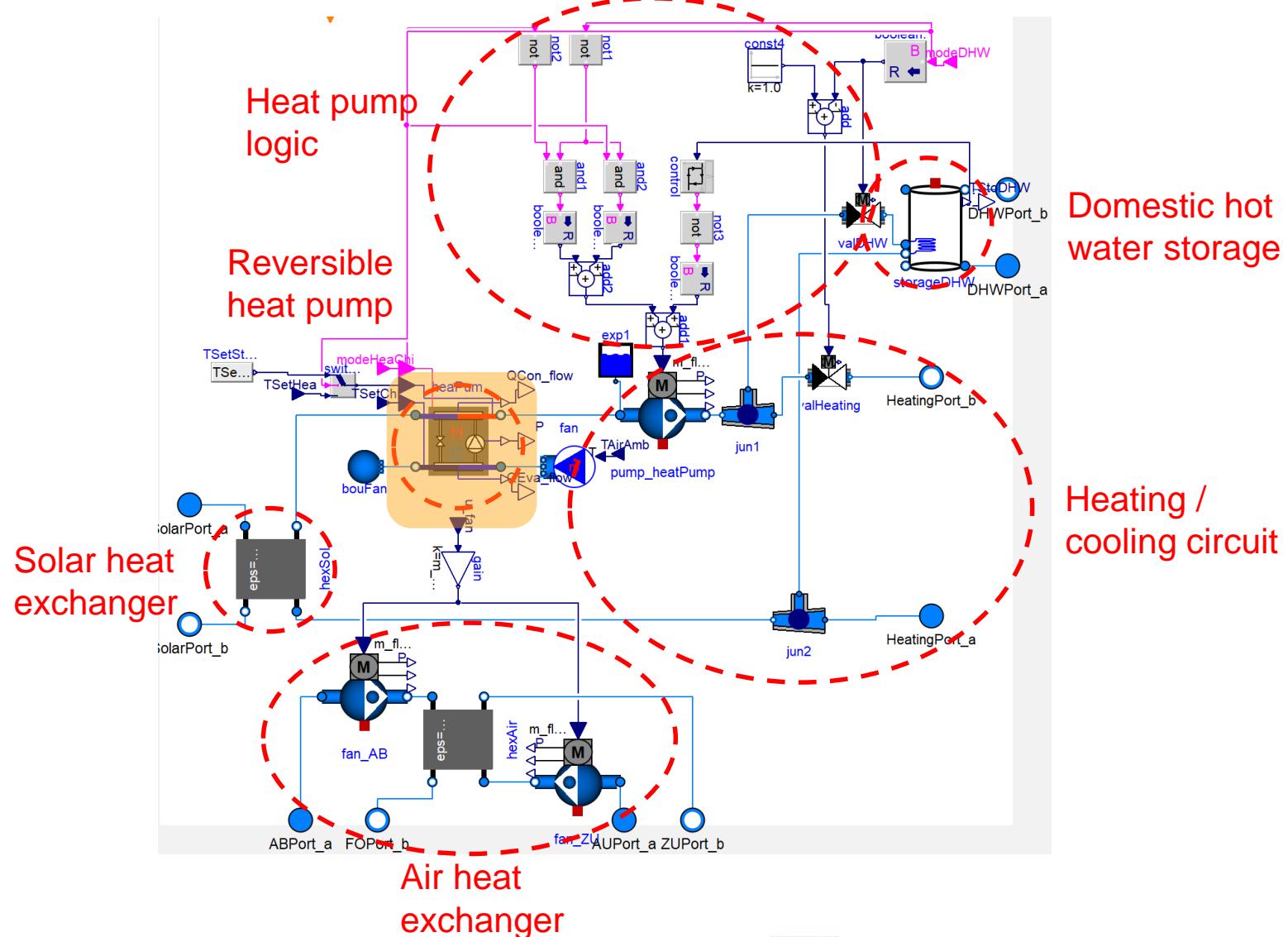
Fachgebiet Versorgungsplanung und Versorgungstechnik
Institut für Architektur und Städtebau



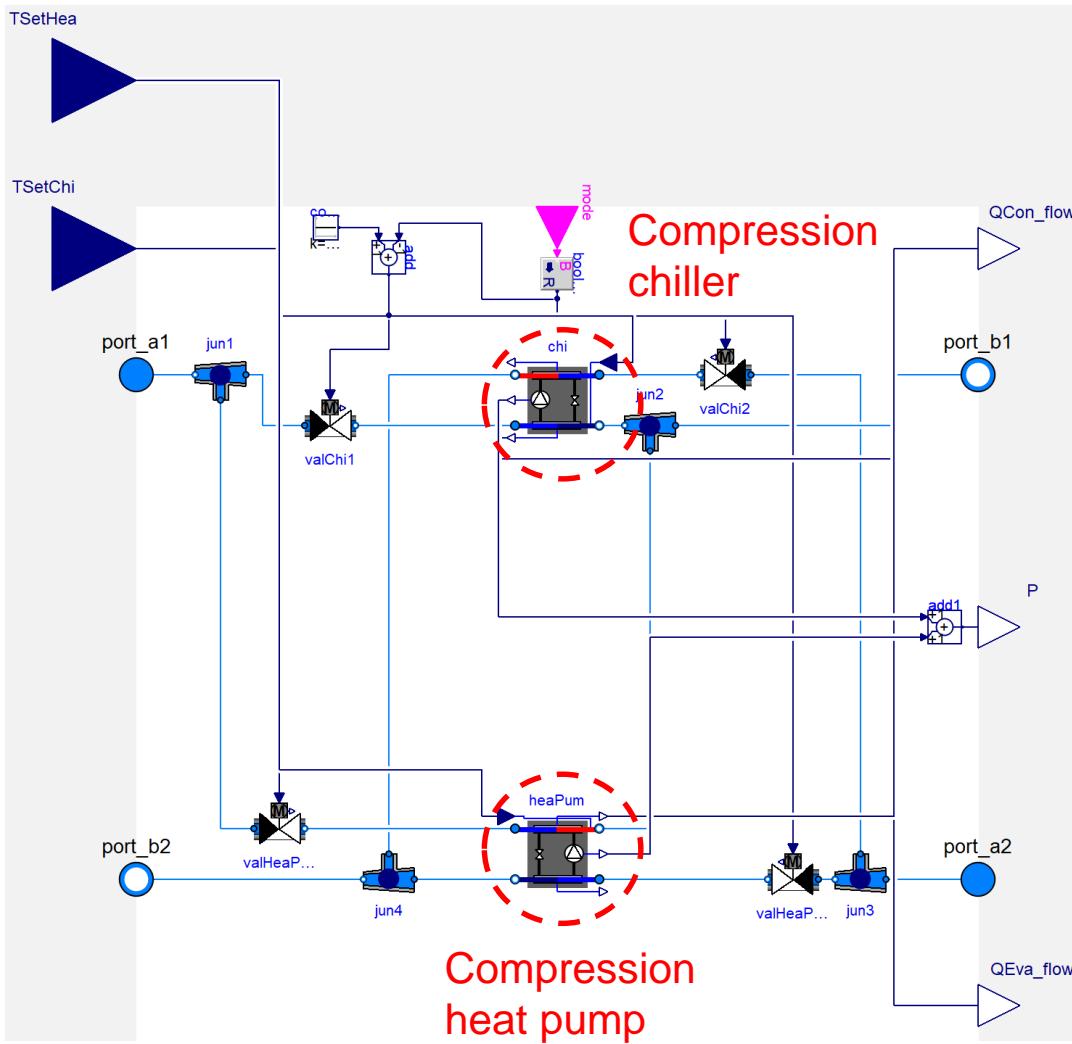
Universität der Künste Berlin



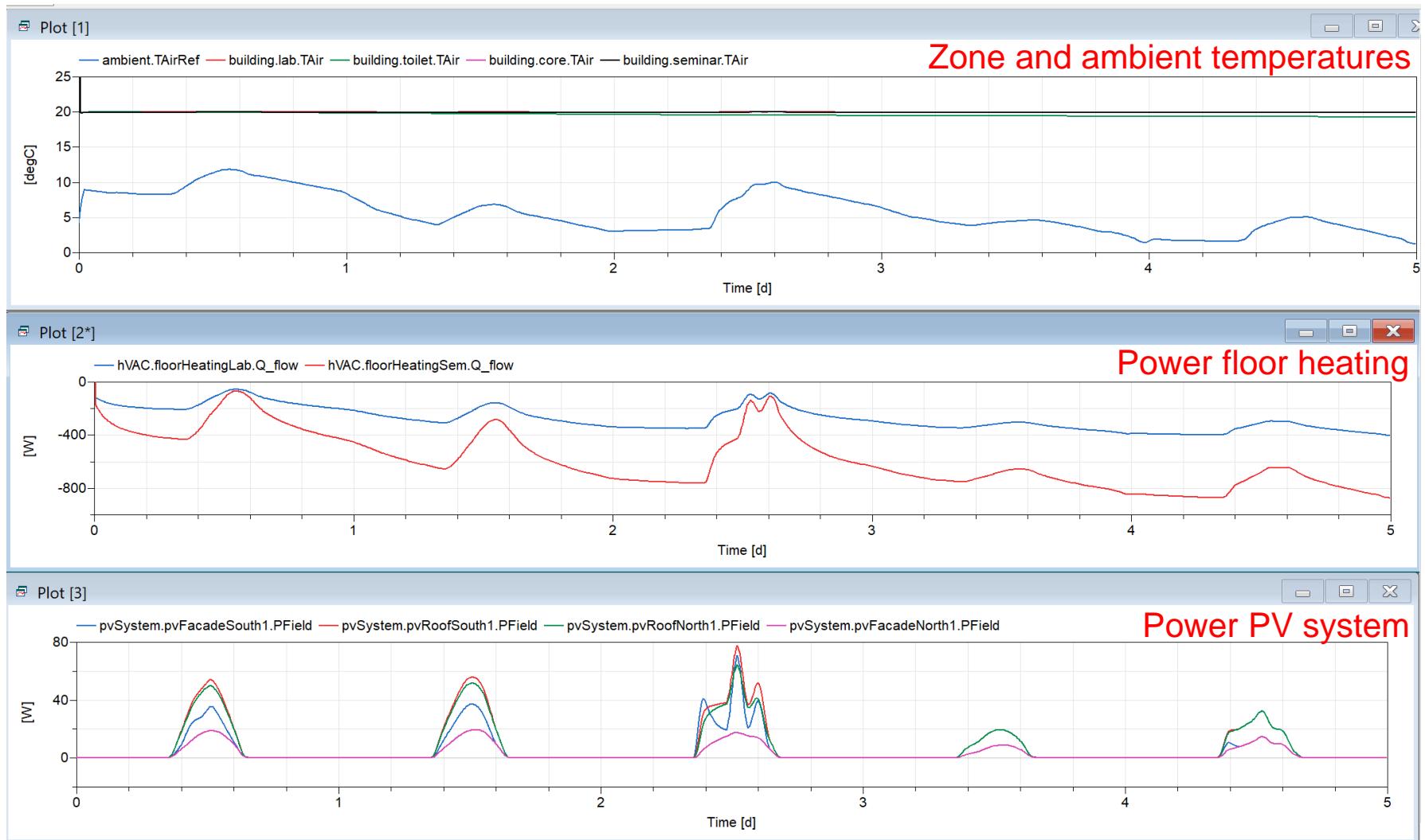
Modelica model of the Rooftop building – Heat pump LWZ 304 SOL



Modelica model of the Rooftop building – Reversible heat pump



Modelica model of the Rooftop building – Simulation results



Discussion

– Positive

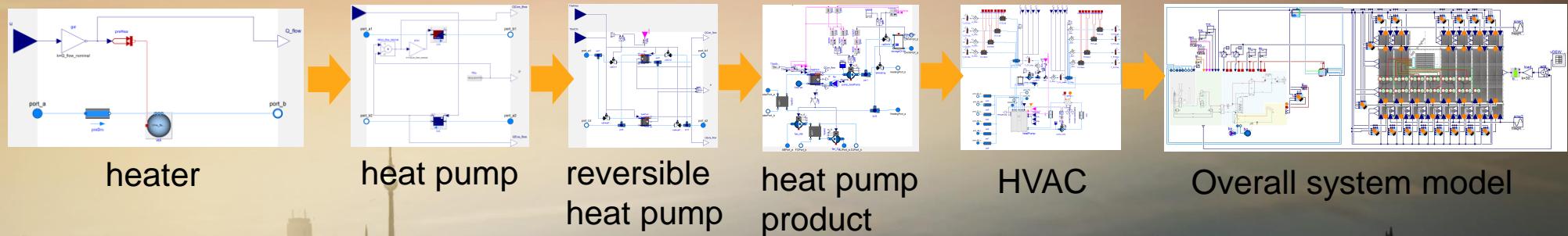
- **Hierarchical model approach** can handle the model complexity
- **Complementary Modelica libraries:** MSL, IBPSA 1, BuildingSystems
- Simulation model is close to the technical structure and the physical behaviour of the real system → „**Digital Twin**“

– Still problematic

- Computational effort for yearly simulation analysis
- Navigation through complex model trees
- Failure identification on top level of the system model

– Possible applications

- **Model validation** (components & system level) under real operation conditions
- **Model-based monitoring** (combination of real and virtual sensors)
- **Evaluation of new control strategies** (history & prognosis based: weather, user behaviour)



Excursion to the real Rooftop building, 1:15 pm

