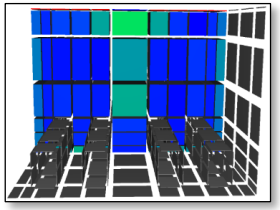
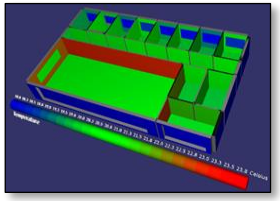
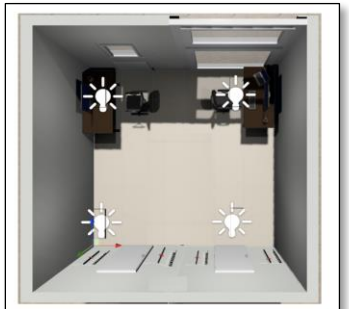
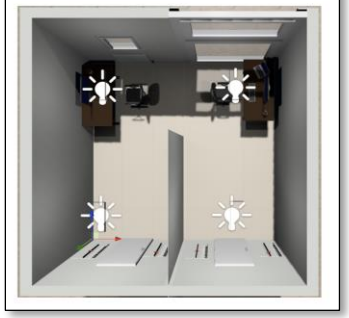
BuildingSystems library from UdK Berlin

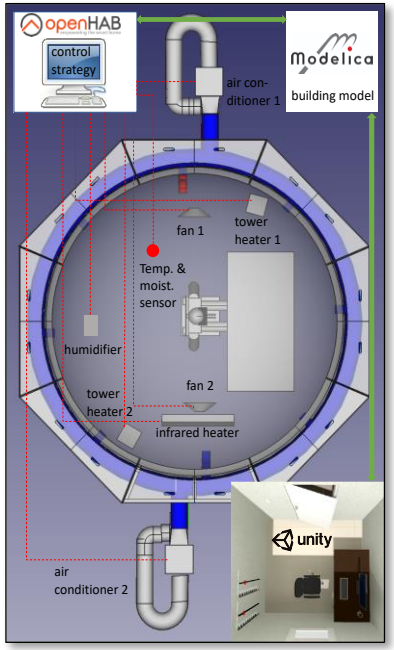
Prof. Dr.-Ing. Christoph Nytsch-Geusen

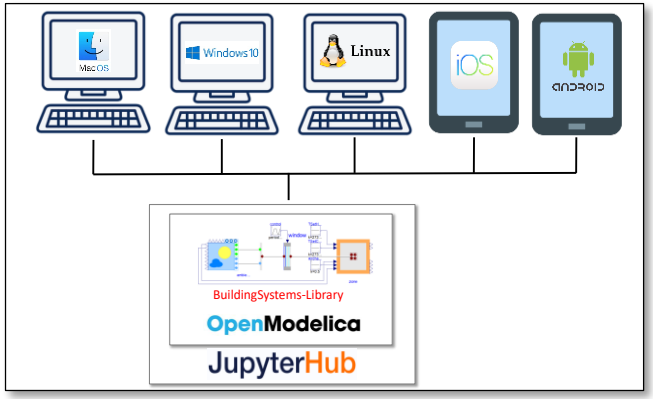


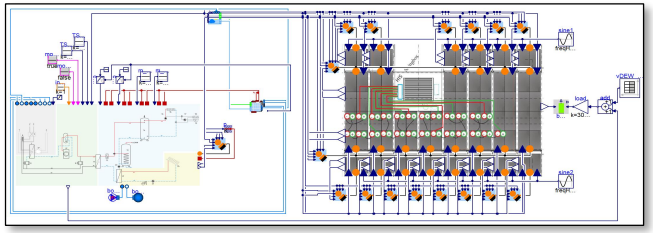












Outline

– **BuildingSystems library**

– **Library Features**

- Integration with the Modelica IBPSA library
- Building energy simulation (BES) on different levels of detail (room, building, district)
- Adaptable building models

– **Library Applications**

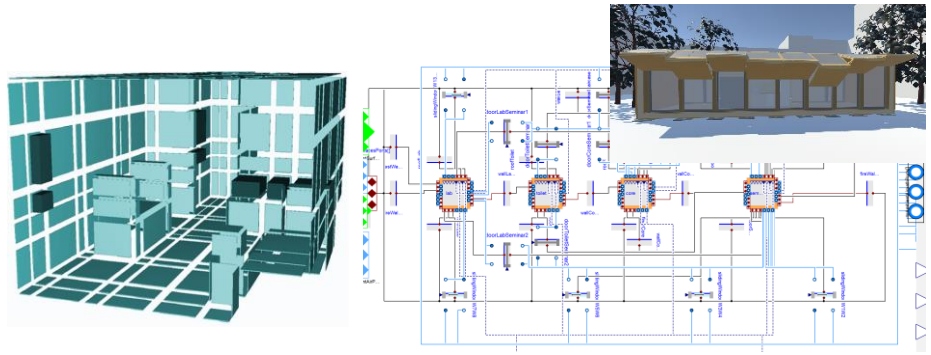
- Digital twins of energy building systems
- Integration of BES into Virtual Reality environments
- Web-based simulation environment

BuildingSystems Library

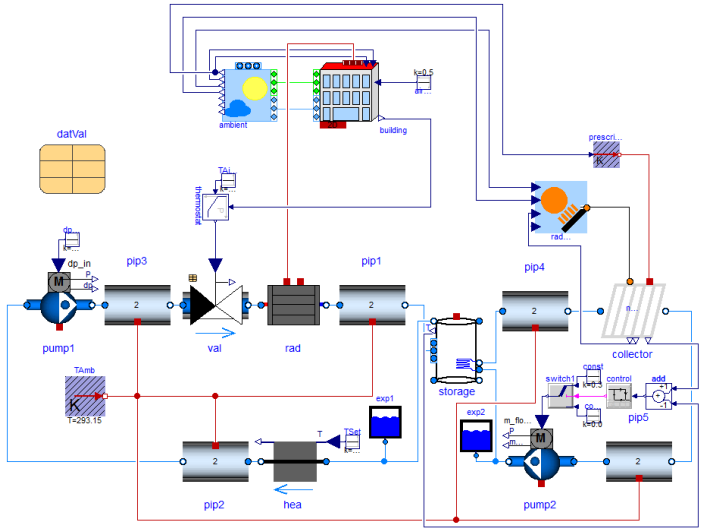
– **Modelica library for energetic simulation of**
  - single constructions, rooms,
  - multi-zone buildings and
  - whole districts.

– **Developed at UdK Berlin**
  - Webpage: http://modelica-buildingsystems.de
  - free available under the BSD 3-Clause license: (https://github.com/UdK-VPT/BuildingSystems)

– **Library models**
  - Building energy simulation
    - simplified and detailed building models (0D, 1D, 3D)
    - thermal and hygro-thermal models
  - Energy plant simulation
    - HVAC systems
    - solar thermal & photovoltaic systems



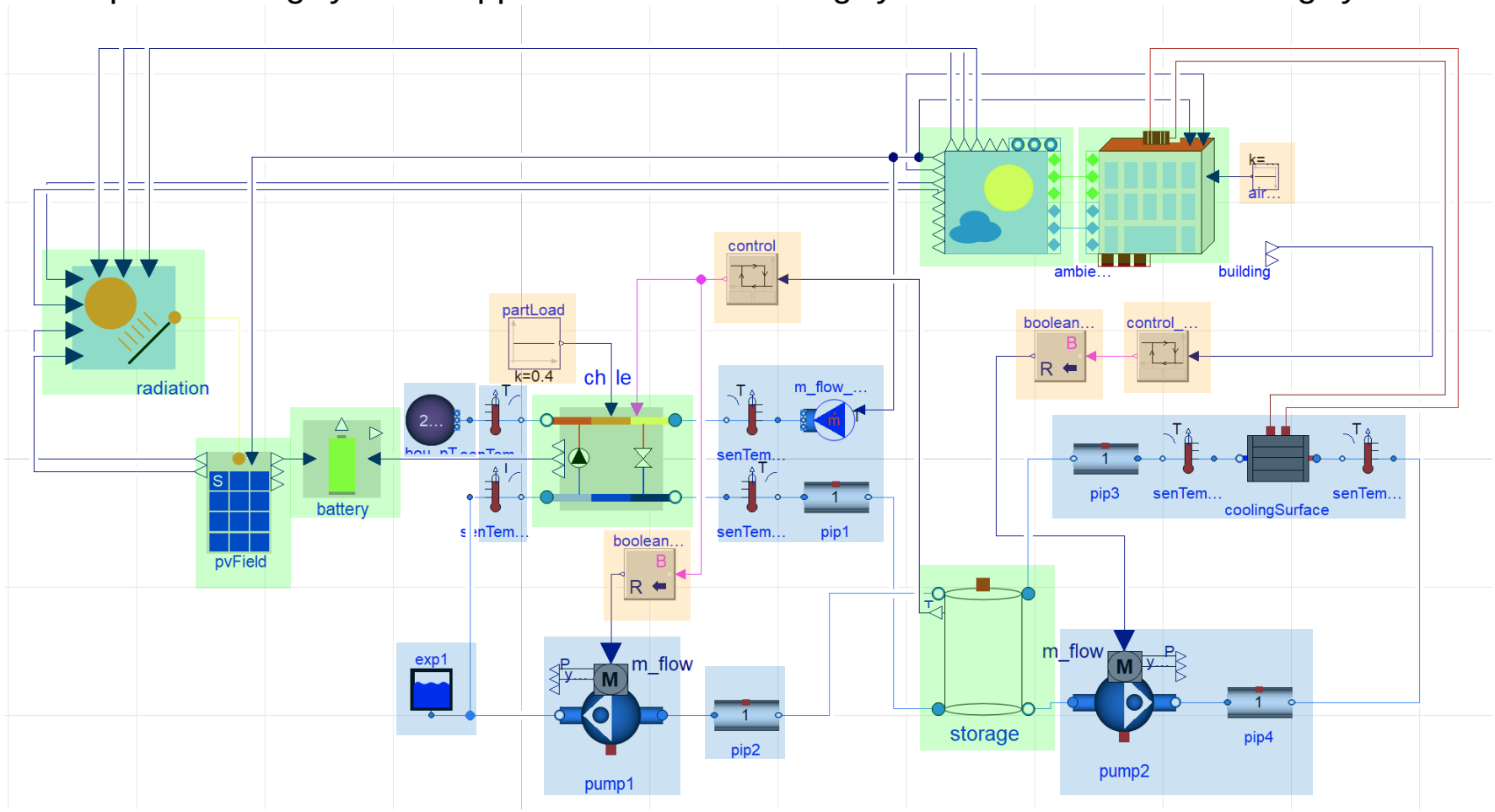
3D spatial resolved room model (left) and multi-zone thermal building model (right)



System model of a solar thermal heating system

Library features - Integration with the Modelica IBPSA library

Example: BuildingSystems.Applications.AirConditingSystems.PhotovoltaicCoolingSystem

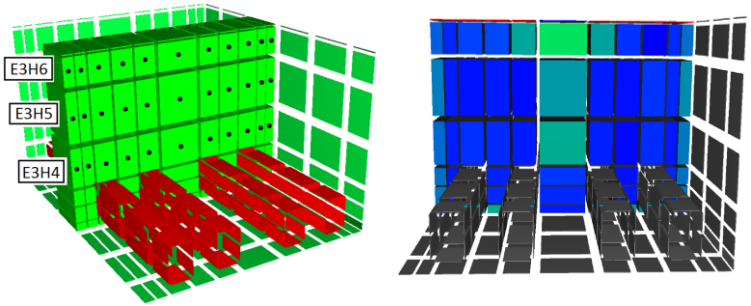


MSL | Modelica_IBPSA | BuildingSystems

Library features – BES on different levels of detail

– **Room Scale**

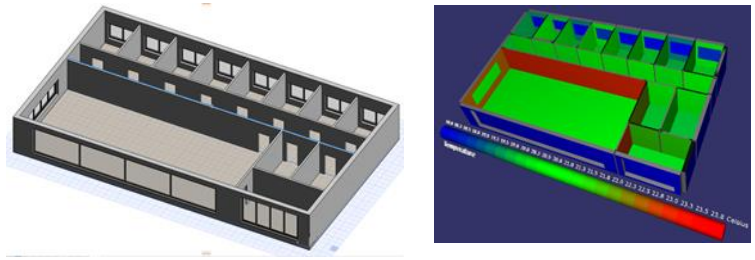
- Finite volume (FV)-based 3D-discritized room model
  → spatial resolved air temperature and velocity field
- Detailed 3D geometries from BIM (e.g. IFC)



FV-based room simulation

– **Building Scale**

- Multi-zone building model
  → mean air/operative temperature for different zones
- Sligthly simplified 1D/3D geometries from BIM



BIM-based building simulation

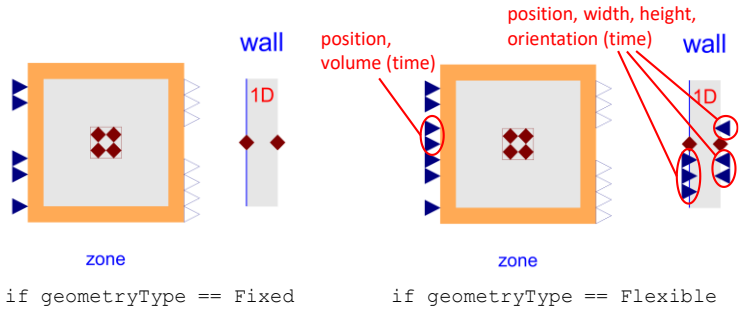
– **District Scale**

- Grey and black box building models
- Strong simplified 0D/1D geometries
  from GIS (ALKIS, CityGML)

GIS-based district simulation

Library features – Adaptable building models

– **Option: Flexible room geometry during simulation runtime**



– **Adaptable wall, door and window models**

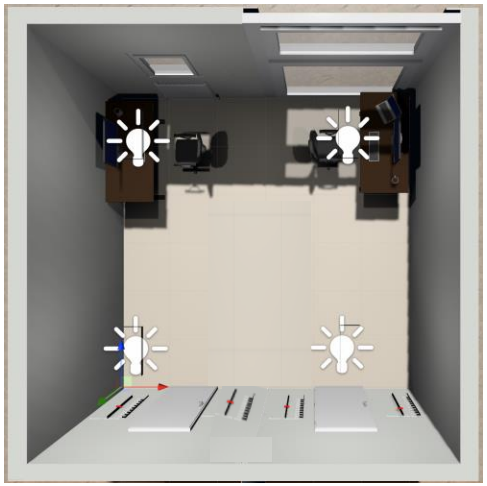
- Geometry: time-dependent position, height, width, azimuth angle and tilt angle

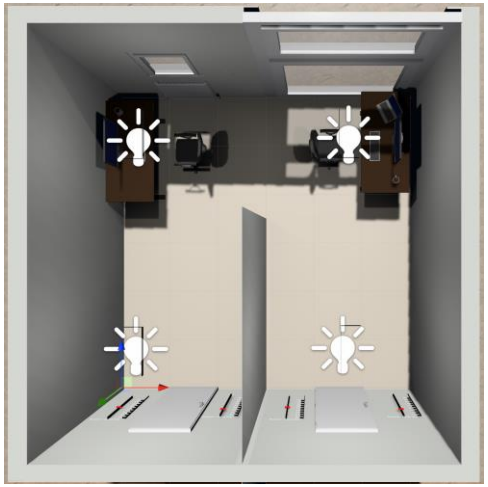
– **Adaptable zone models**

- Geometry: time-dependent position and volume
- Radiation exchange: time-dependent view factor calculation

– **Example: movable divider wall between two zones (right)**

- wall geometry can change by user interaction
- Long-wave radiation exchange between all zone surfaces dependent on the divider wall size and position





Room model with a movable divider wall

Library Applications – Digital twins of building energy systems

Real building system

(Rooftop building: www.solar-rooftop.de)

Building construction

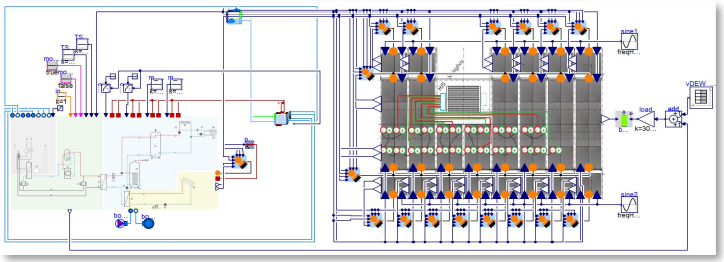
Building energy technology (HVAC)

Sensors & actuators

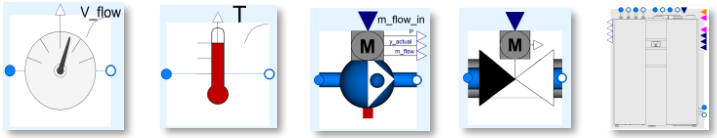
Digital twin

Multi-zone thermal building model

Energy plant model

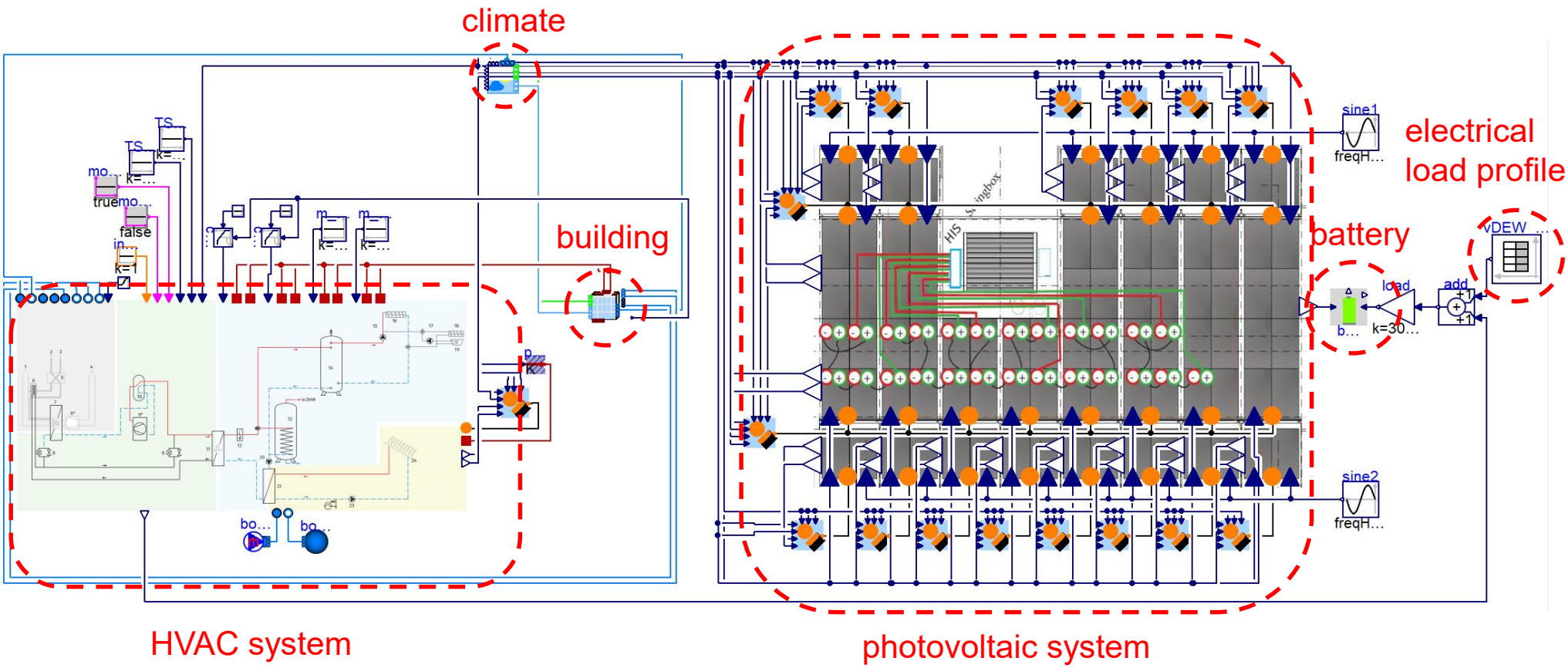


“Virtual” sensors & actuators



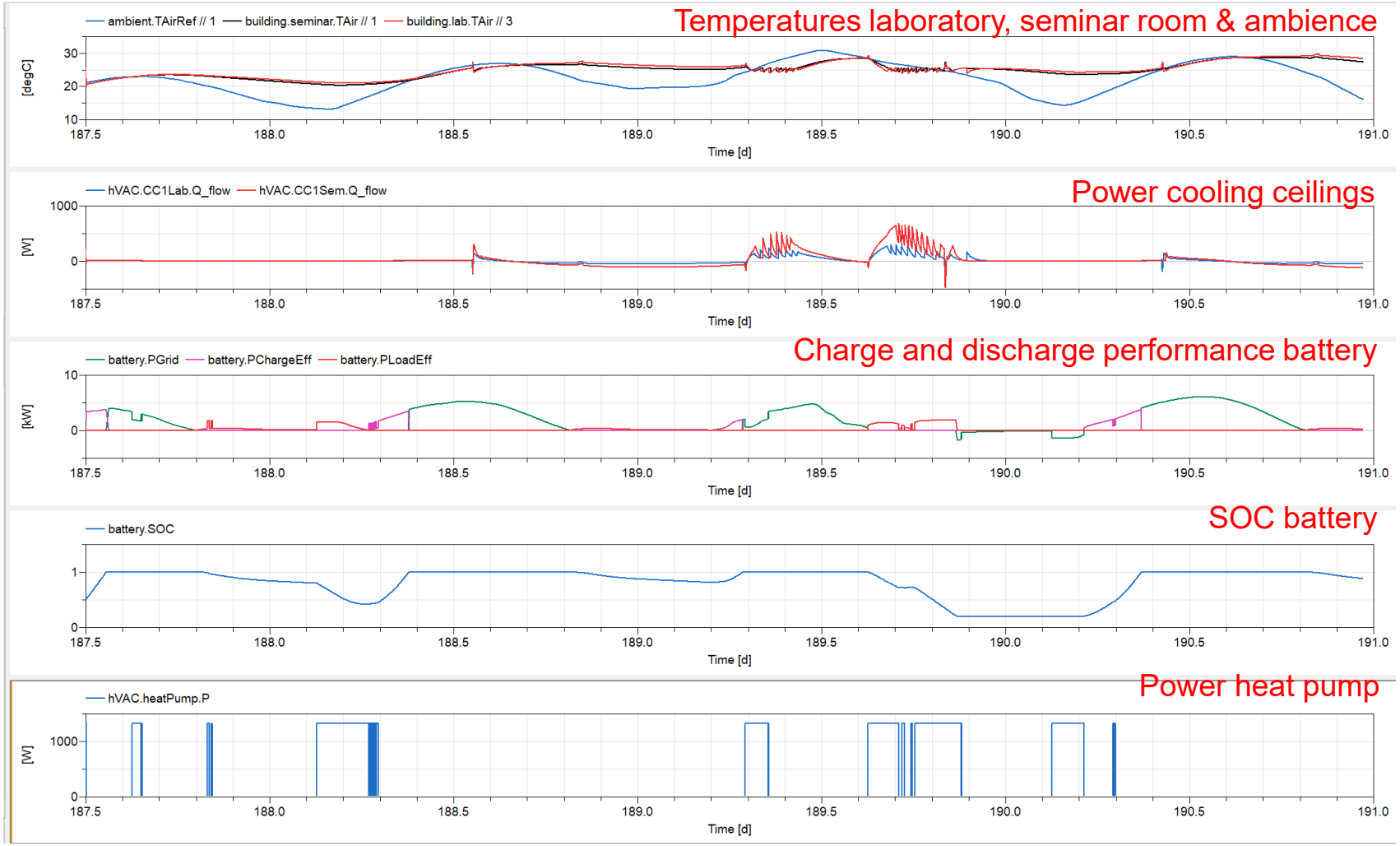
Library Applications – Digital twins of building energy systems

Modelica model of the energy building system of the Rooftop building from UdK Berlin



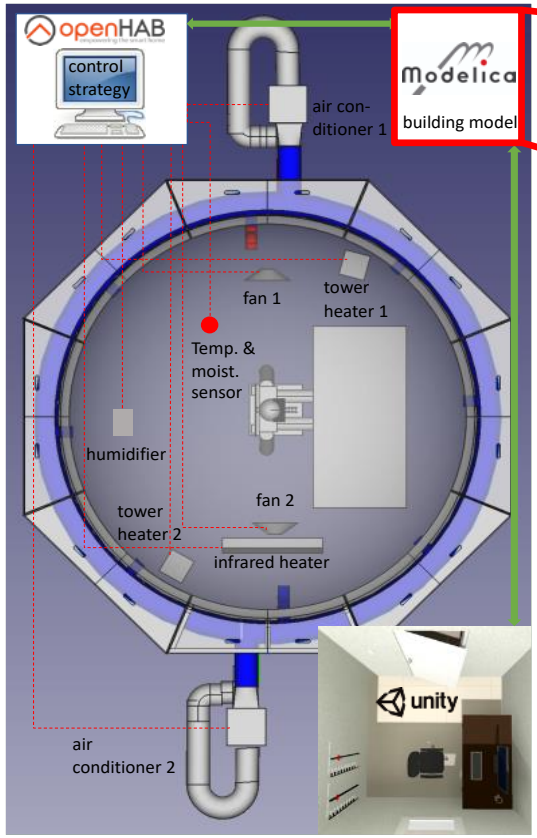
Library Applications – Digital twins of building energy systems

Rooftop building - Simulation analysis of a summer period

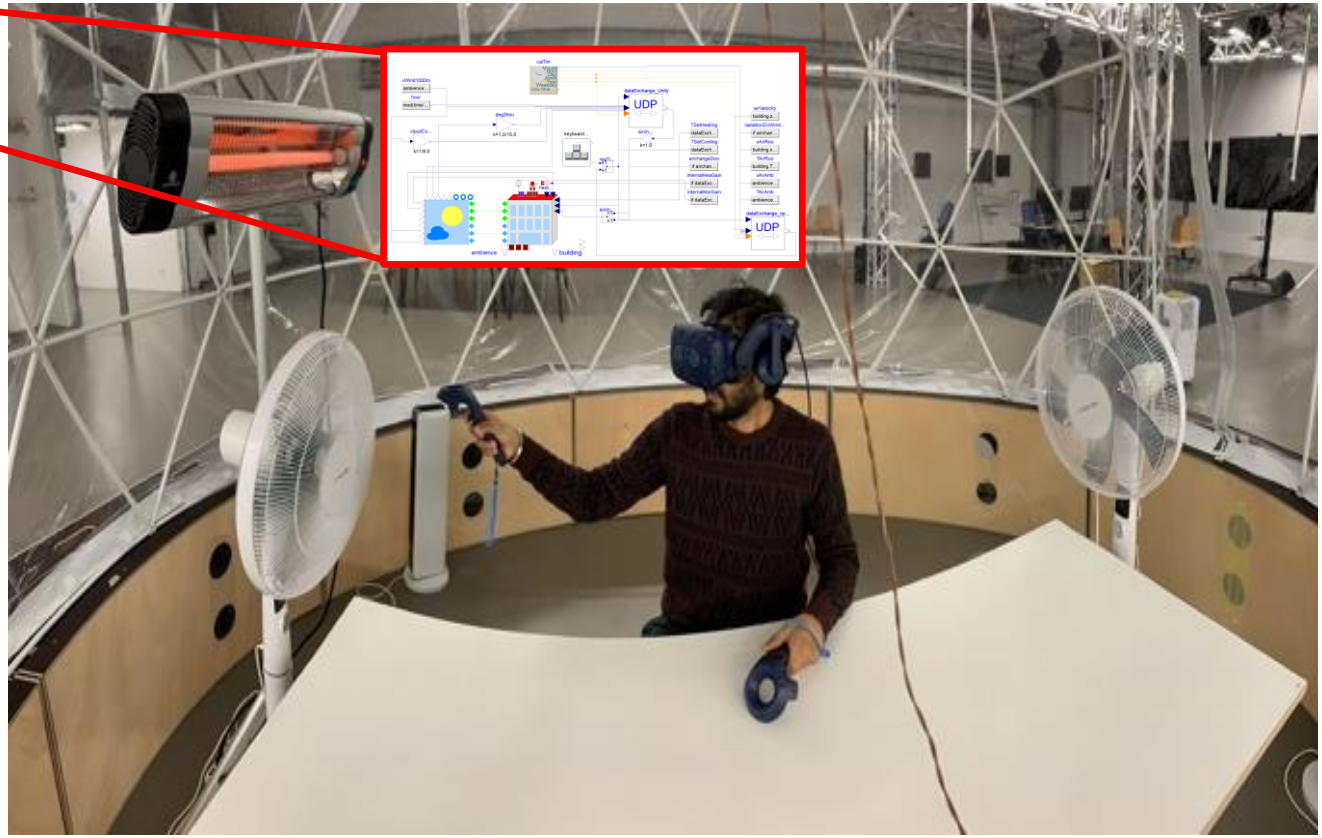


Library Applications - Integration of BES into Virtual Reality environments

Interactive immersive VR simulation environment with a thermal feedback for the user



Hard and software integration

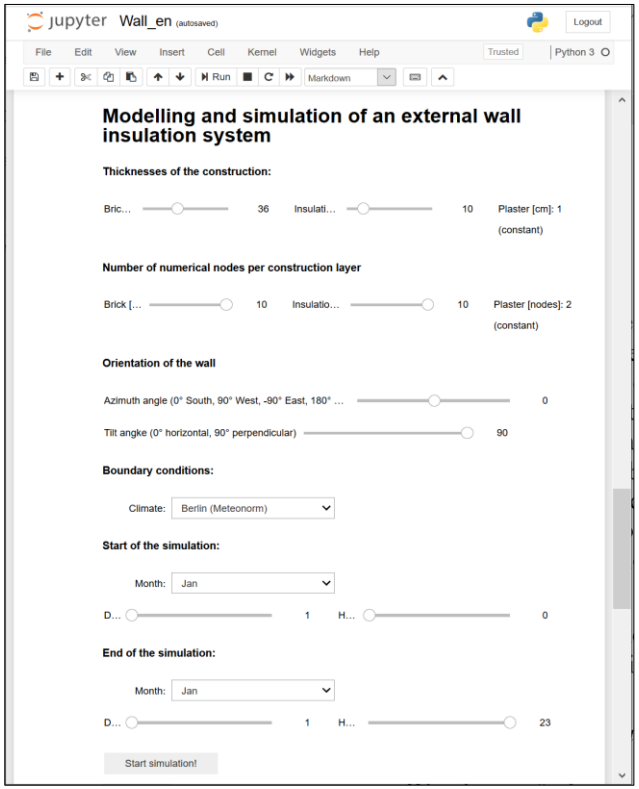


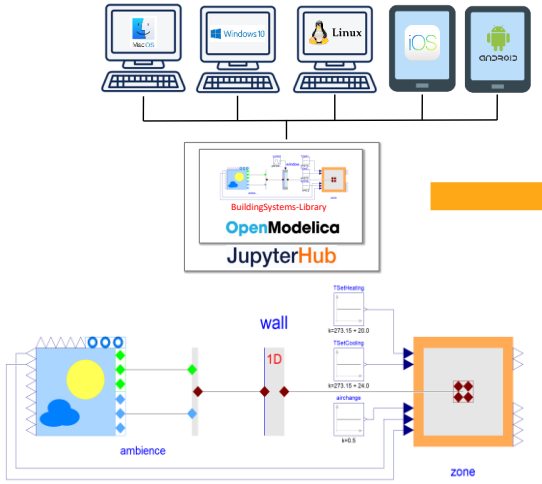
VR user in the climate chamber surrounded by devices for indoor climate reproduction

a) Research approach https://youtu.be/gyU_0Ixzx9A
b) Demonstration of the VR simulation environment https://youtu.be/a0GnX5KZit4

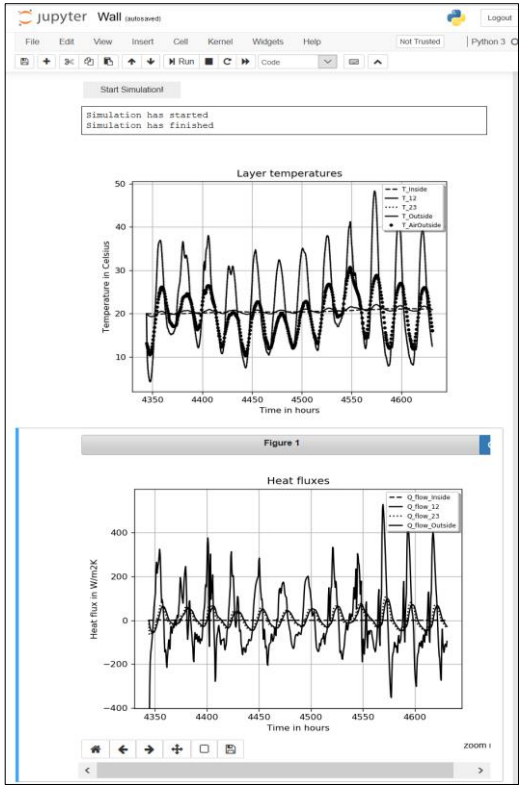
Library Applications - Web-based simulation environment

Simulation core and user network





- Thickness of brick and insulation layer
- Number of numerical nodes per layer
- Orientierung of the wall
- Steady state or dynamic boundary conditions
- Simulation time period
- …



Model parameterization

Simulation results

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