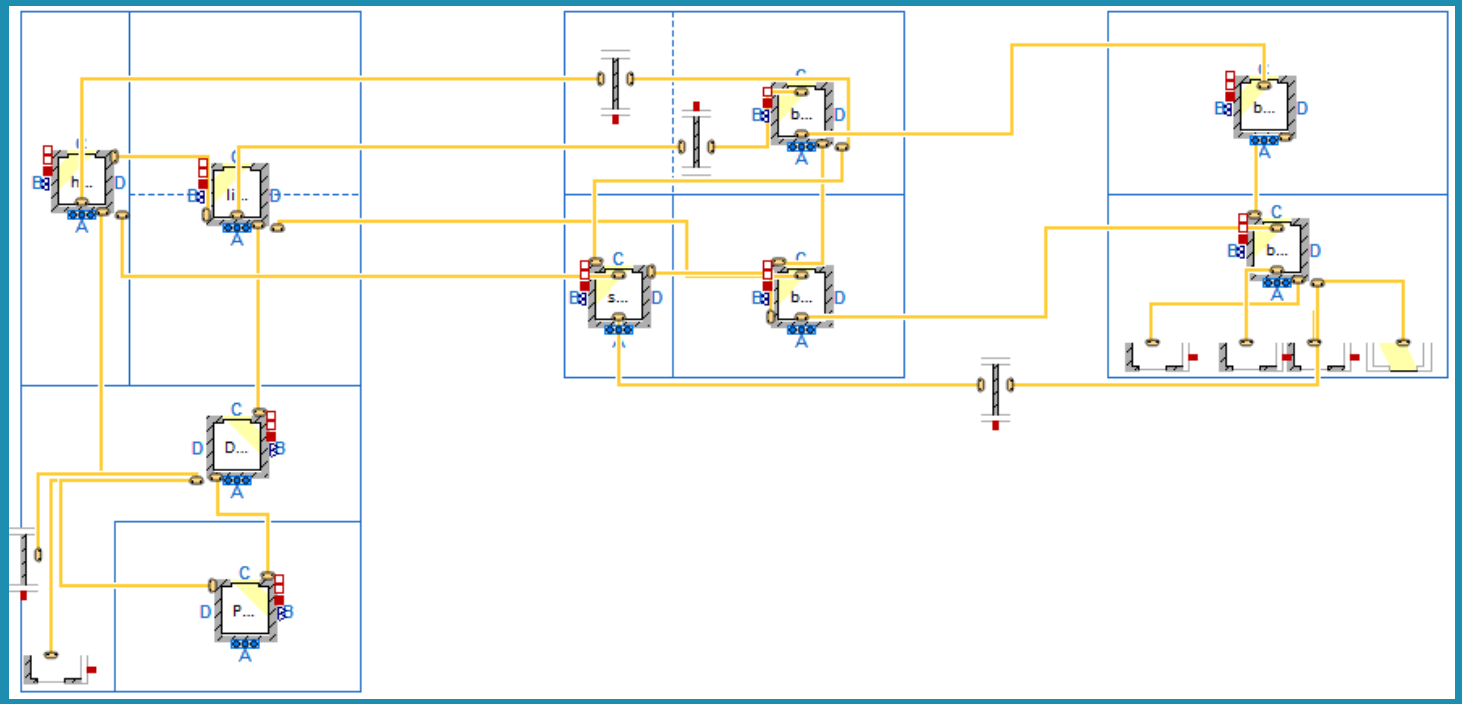
KU LEUVEN

THERMAL SYSTEMS SIMULATION

IDEAS library



Jelger Jansen

Modelica Conference 2023

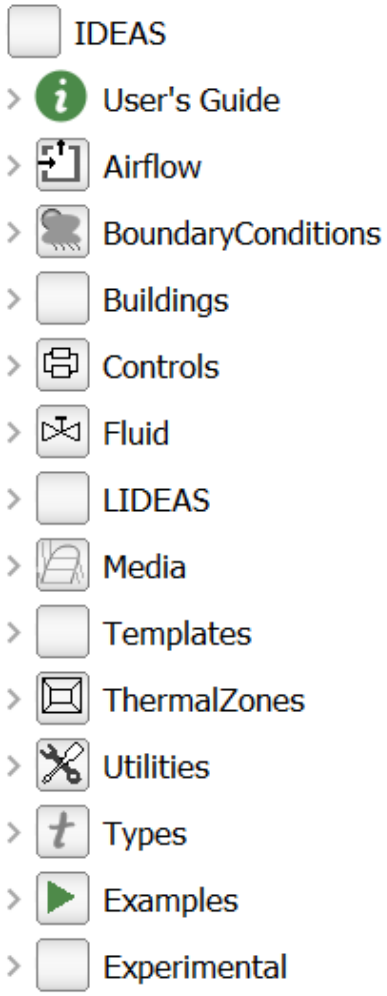
09/10/2023

Integrated District Energy Assessment Simulations

- Modelica users and library development since 2010
- Focus
  - Initial: integrated building and district simulations (electrical and thermal)
  - Later: building level (thermal)
- Research tool
  - Main users: researchers, students
  - ! Some companies started using it
- IDEAS v1.0 released in 2017

  F. Jorissen, G. Reynders, R. Baetens, D. Picard, D. Saelens, and L. Helsen. (2018) Implementation and Verification of the IDEAS Building Energy Simulation Library. Journal of Building Performance Simulation, 11 (6), 669-688, doi: 10.1080/19401493.2018.1428361.
- IDEAS v3.0 released in 2022

Package overview

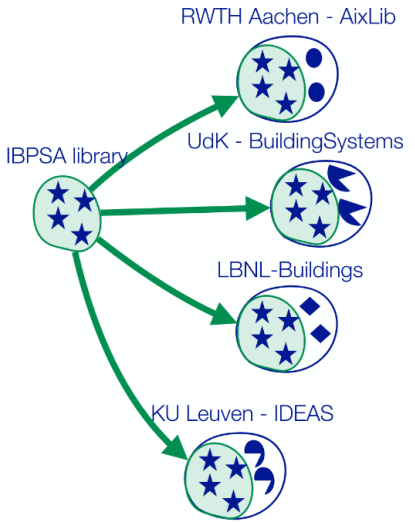


Fluid package – mainly IBPSA

- IDEAS
  - User's Guide
  - Airflow
  - BoundaryConditions
  - Buildings
  - Controls
  - Fluid
  - LIDEAS
  - Media
  - Templates
  - ThermalZones
  - Utilities
  - Types
  - Examples
  - Experimental

- Fluid
  - UsersGuide
  - Actuators
  - Chillers
  - Delays
  - FMI
  - FixedResistances
  - Geothermal
  - HeatExchangers
  - HeatPumps
  - Humidifiers
  - MassExchangers
  - MixingVolumes
  - Movers
  - Sensors
  - Sources
  - Storage
  - Taps
  - Types
  - Examples
  - Interfaces
  - BaseClasses

International Building Performance Simulation Association



THERMAL SYSTEMS SIMULATION

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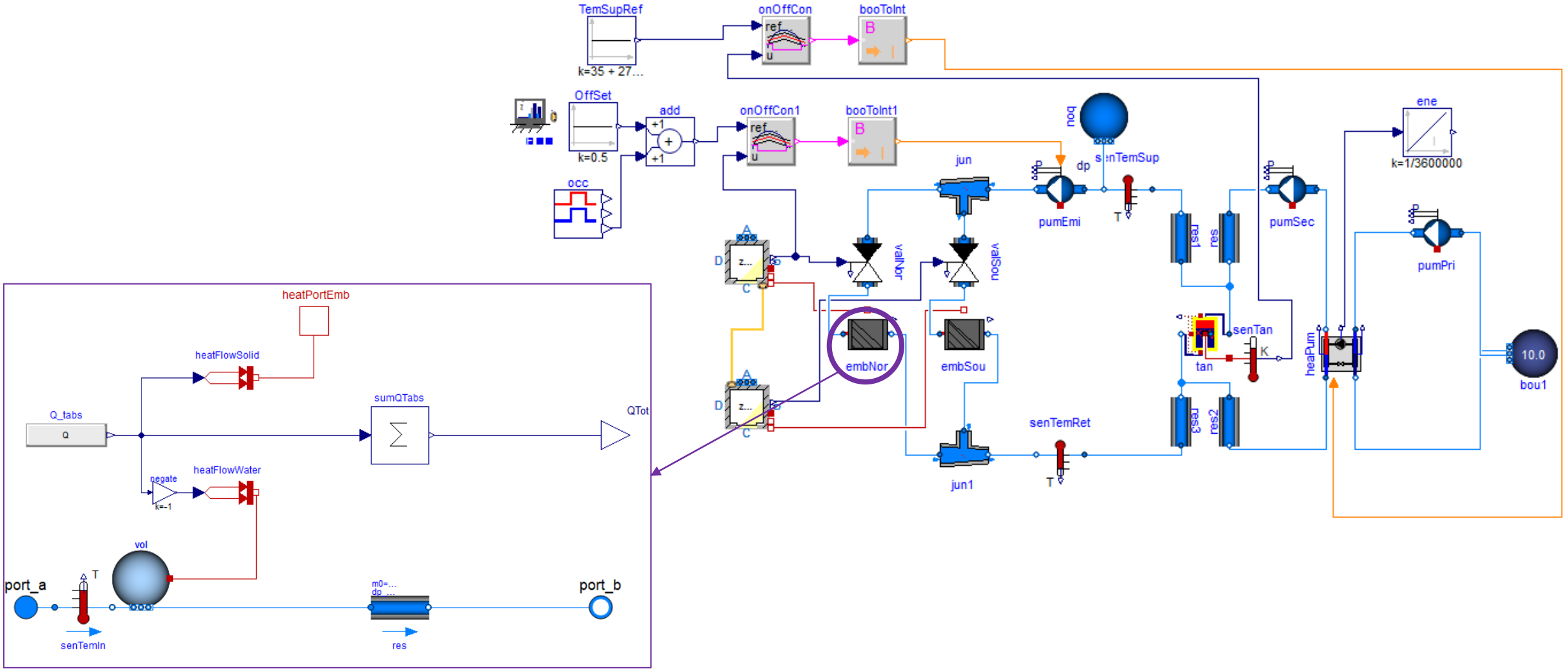
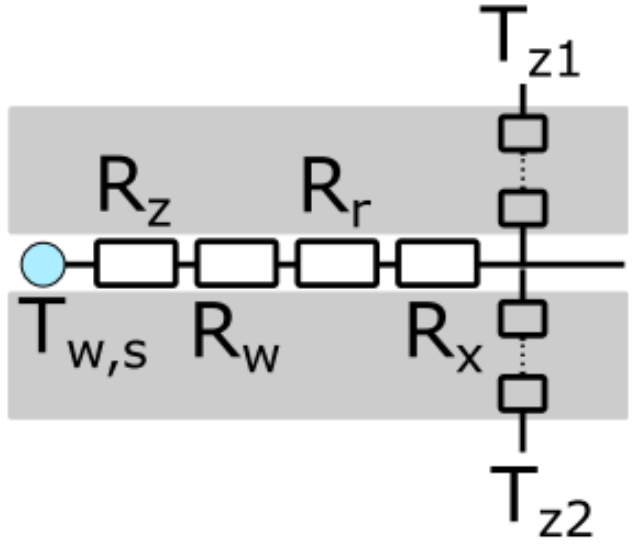
TABS/floor heating



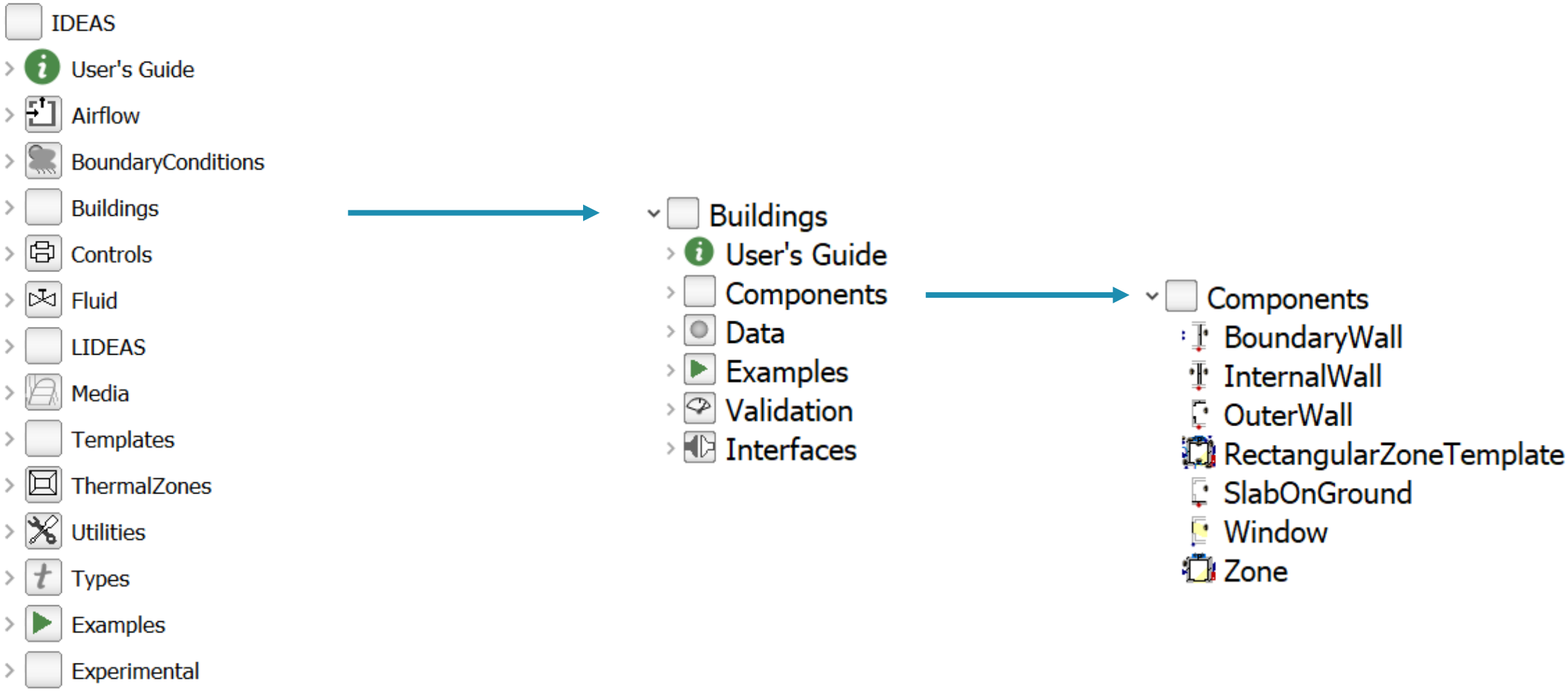
TABS/floor heating

- Represents embedded pipe in the concrete
- Connect to layer of internal wall (floor/ceiling) of building model to inject heat
- Model of Koschenz and Lehman
  M. Koschenz and B. Lehmann, *Thermoaktive Bauteilsysteme tabs*. Dübendorf, Switzerland: EMPA Energyiesysteme/Haustechnik, 2000.
  - 3D heat diffusion → 1D thermal resistance model
  - Resistance values depend on
    - Pipe and wall layer (concrete slab)
      - Thermal properties
      - Dimensions
    - Pipe spacing

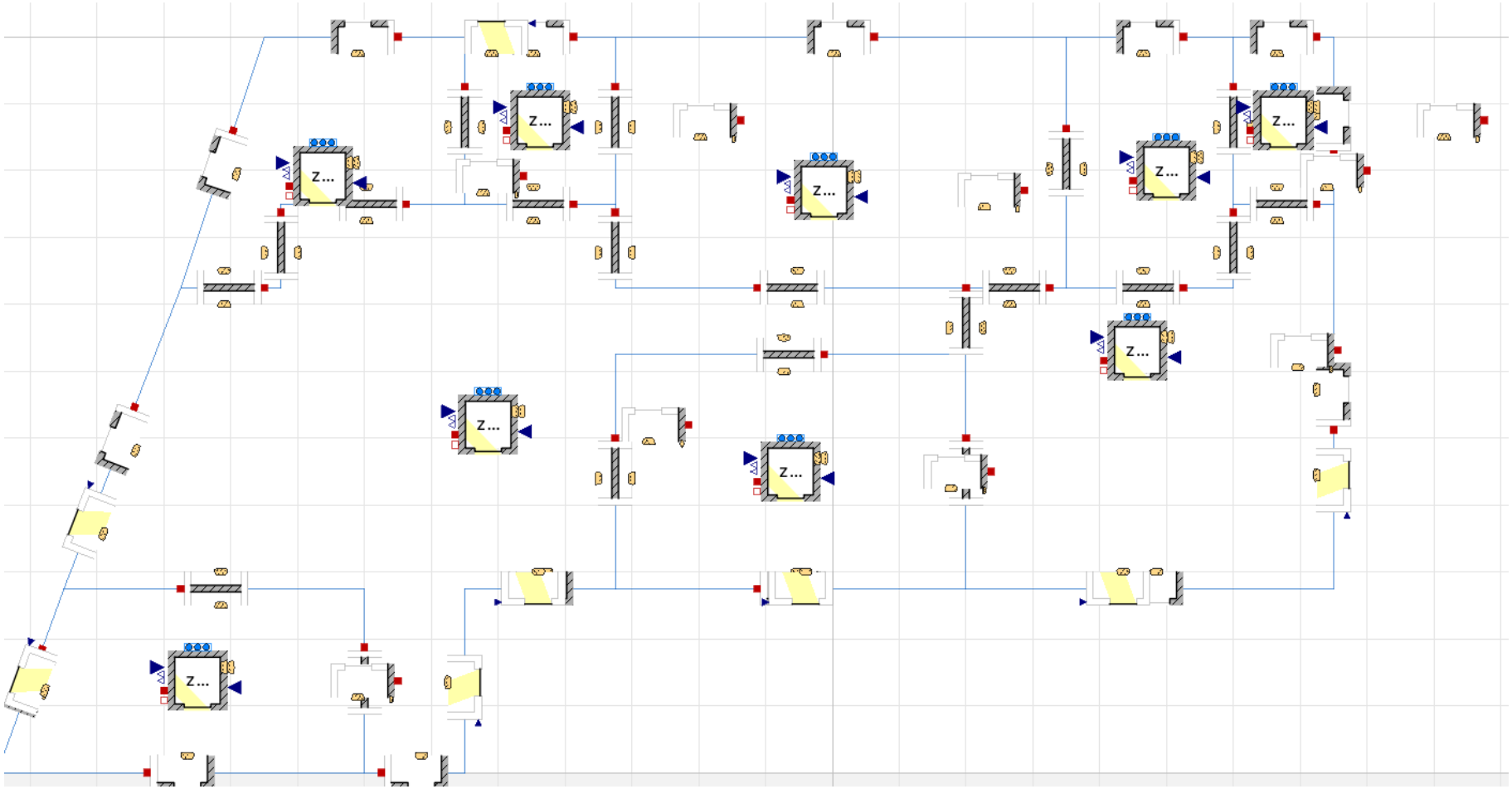


D. Picard, “Modeling, Optimal Control and HVAC Design of Large Buildings using Ground Source Heat Pump Systems,” PhD thesis, KU Leuven, Belgium, 2017.

Buildings package – our focus



Physics-based (white-box) modelling



➔ Direct mapping between physical objects and components

Parameters

Zone

General | Advanced | Airflow | Initialization | Add modifiers | Attributes

Component

Name	zone
Comment	Zone model

Icon

Model

Path	IDEAS.Buildings.Components.Zone
Comment	Building zone model

Parameters

Medium	Medium		Medium in the component
nSurf	7		Number of surfaces adjacent to and heat exchanging with the zone
nPorts	2		Number of ports for ventilation connections
energyDynamicsAir	Modelica.Fluid.Types.Dynamics.Fix		Type of energy balance for air model: dynamic (3 initialization options) or steady state

Building physics

V	l*h*w	m³	Total zone air volume
hZone	2.8	m	Zone height: distance between floor and ceiling
hFloor	0	m	Absolute height of zone floor
A	V/hZone	m²	Total conditioned floor area

Occupants (optional)

occNum	redeclare IDEAS.Buildings.Component	Number of occupants that are present
occTyp	redeclare parameter IDEAS.Buildings.(	Occupancy type, only used for evaluating occupancy model and comfort model
comfort	redeclare IDEAS.Buildings.Component	Comfort model

Lighting (optional)

rooTyp	redeclare parameter IDEAS.Buildings.C	Room type or function, currently only determines the desired lighting intensity
ligTyp	redeclare parameter IDEAS.Buildings.C	Lighting type, determines the lighting efficacy/efficiency
ligCtr	redeclare IDEAS.Buildings.Components.	Lighting control type

Wall

General | Advanced | Dynamics | Convection | Airflow | Radiation | Add modifiers | Attributes

Component

Name	outerWall
Comment	Outer wall model

Icon

Model

Path	IDEAS.Buildings.Components.OuterWall
Comment	Opaque building envelope construction

Parameters

incOpt	○ Wall ○ Floor ○ Ceiling ◉ Custom		Tilt angle option from simInfoManager, or custom using inc
inc	IDEAS.Types.Tilt.Wall	rad	Custom inclination (tilt) angle of the wall, default wall
aziOpt	○ South ○ West ○ North ○ East ◉ Custom		Azimuth angle option from simInfoManager, or custom using azi
azi	IDEAS.Types.Azimuth.W	rad	Custom azimuth angle of the wall, default south
A	l*h	m²	Component surface area
hVertical	if IDEAS.Utilities.Math.Functions.isAngle(in		Vertical surface height, height of the surface projected to the vertical, 0 for floors and ceilings
hRef_a	if IDEAS.Utilities.Math.Functions.isAngle(in		Height above the zone floor at propsbus_a. Height where the surface starts. e.g. 0 for walls at floor level and floors.

Construction details

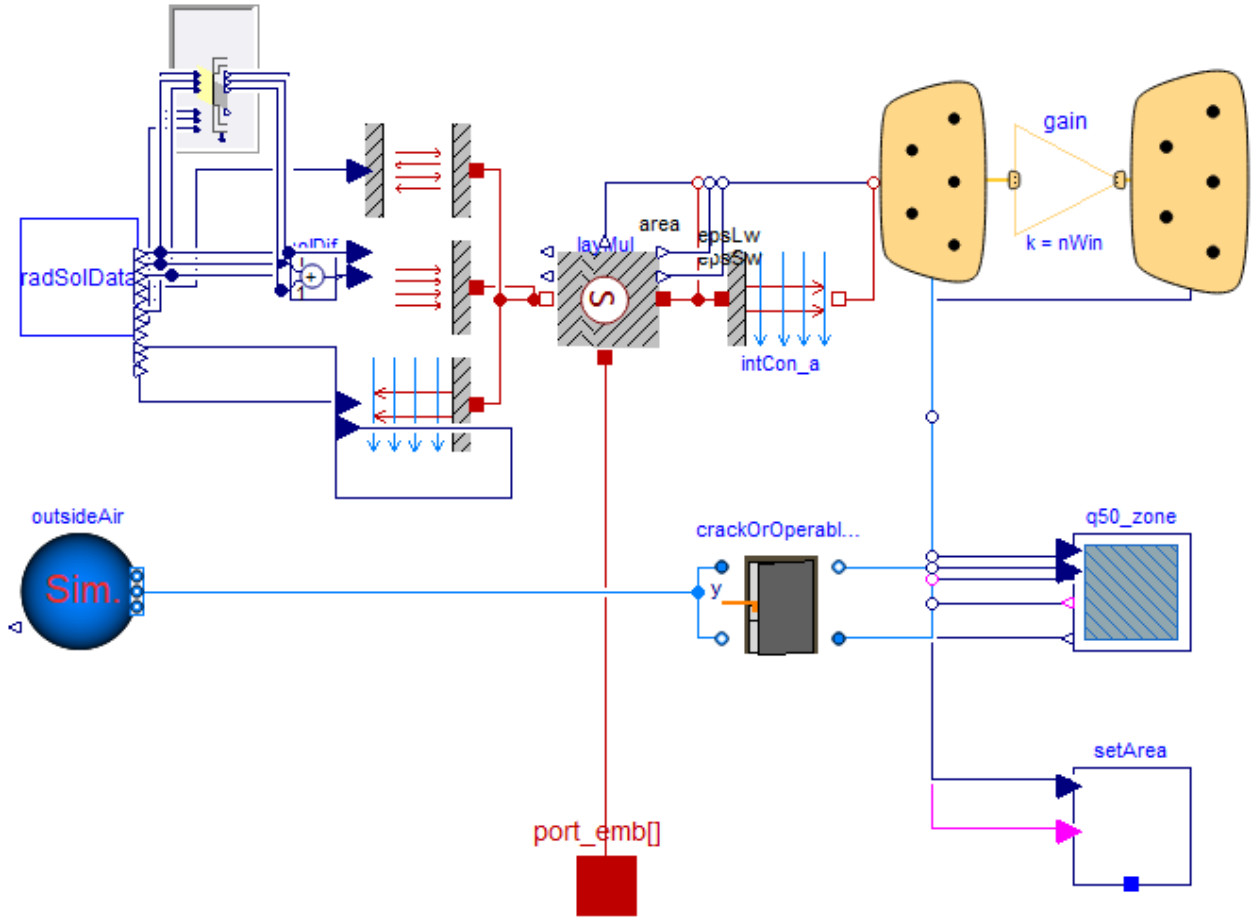
constructionType	redeclare IDEAS.Buildings.Validation.Data.Constructions.HeavyWall constructionT	Building component material structure

Building shade

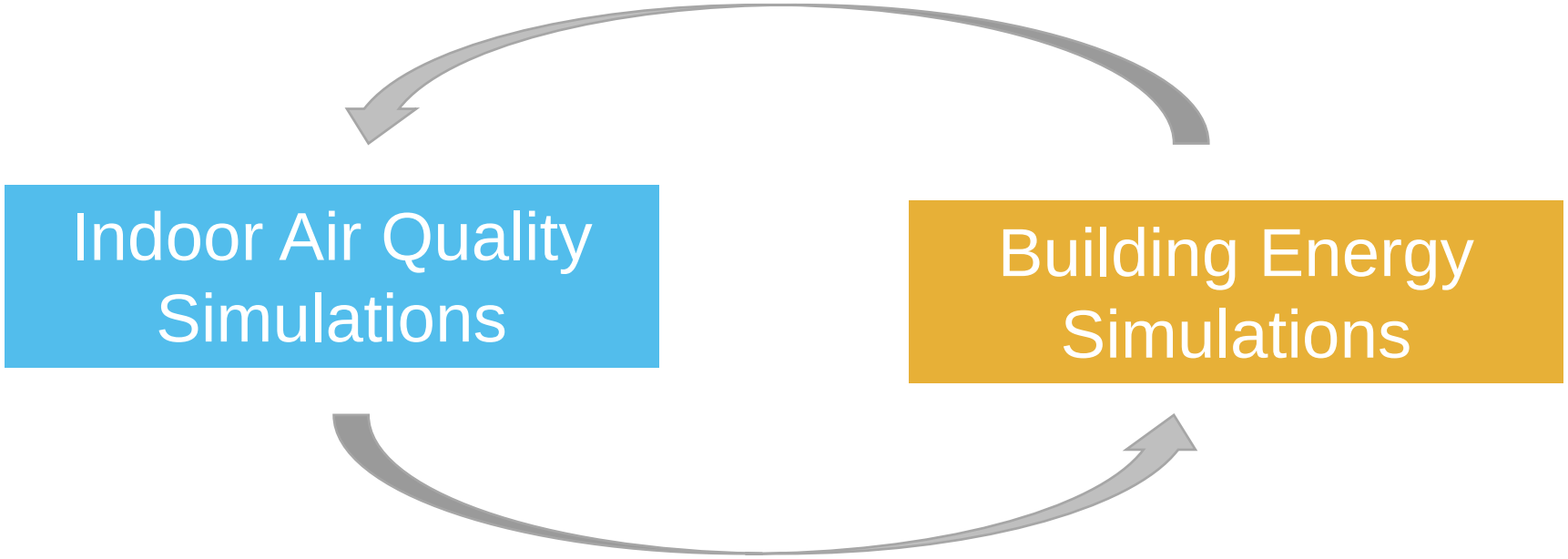
hasBuildingShade	false		=true, to enable computation of shade cast by opposite building or object
L	0	m	Distance between object and wall, perpendicular to wall
dh	0	m	Height difference between top of object and top of wall
hWal	0	m	Wall height

Main building physics

- Conduction, thermal mass
- Convective heat transfer
- Radiative heat transfer
- Shortwave heat gains (incl. shading)
- Internal heat gains (occupants, lighting)
- **Integrated infiltration** and **interzonal airflow**



Integrated pressure-driven air flow modelling

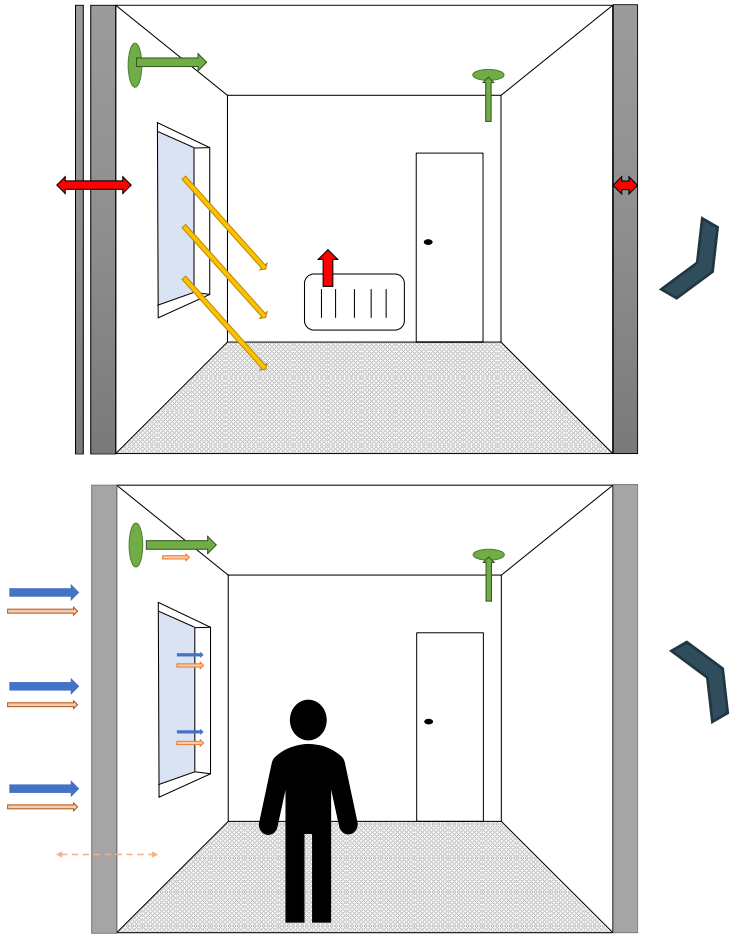


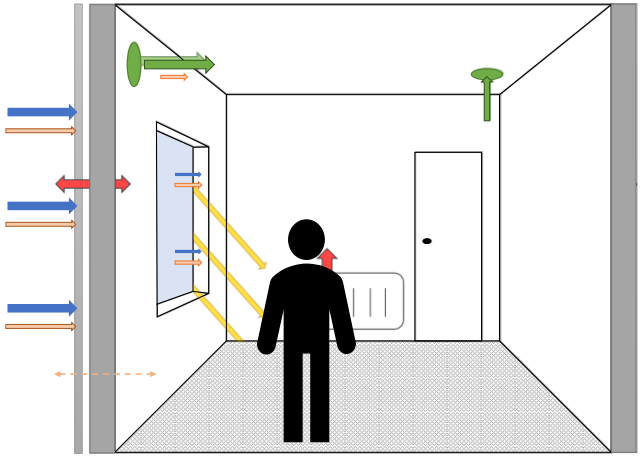
Integrated pressure-driven air flow modelling

Existing building energy simulation models
[IDEAS]

Airflow elements
[K. De Jonge -> IBPSA]

GHENT UNIVERSITY





Integrated coupled energy and airflow solution

Integrated pressure-driven air flow modelling

Now

- Good default implementation
- All naturally-driven flows included: infiltration, interzonal, stack effect (WIP)
- Low input effort for infiltration modelling: only n50 (ACH50), but expert overrides available
  - Dynamic wind-pressures
  - Openings in walls/floors automatically converted to orifice models
  - Density column heights derived from building zone and element parameters
- Models are validated using CONTAM (state-of-the-art airflow models)

Future (Ghent University)

- Humidity buffering
- Pollutant dynamics
- Easily access pollutant concentration for demand-controlled systems