Modelica Buildings Library

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October 9, 2023

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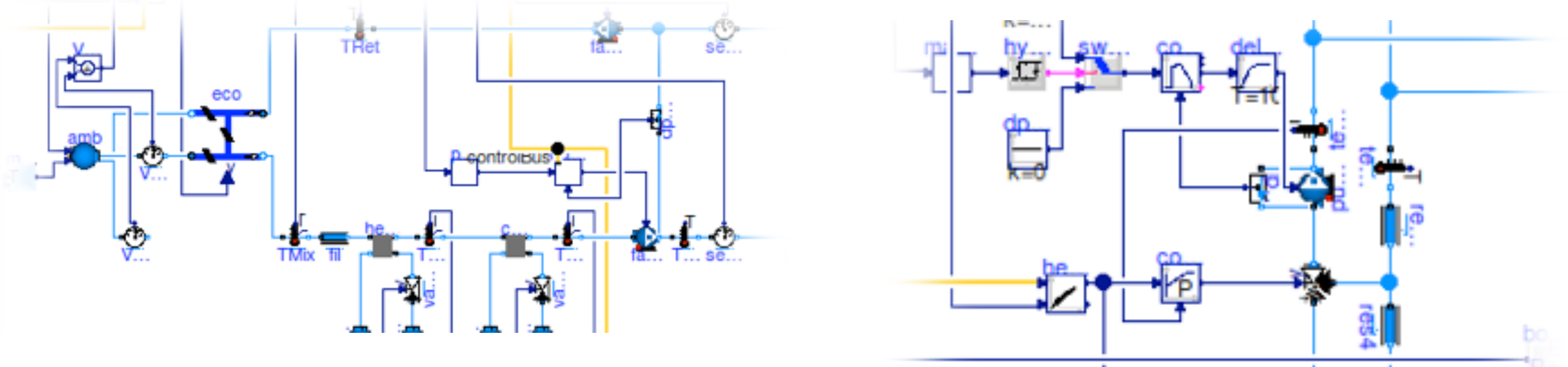
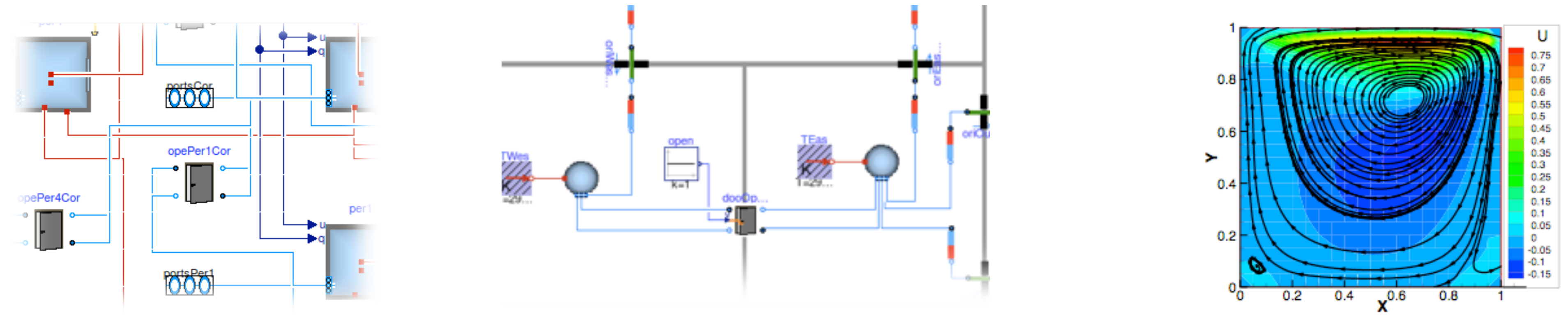
Modelica Buildings Library and Spawn for district energy modeling

Open-source repository of 2000+ models and functions, 45+ contributors, most cited paper in Journal of Building Performance Simulation since a few years. Co-develop with IBPSA Modelica Library.

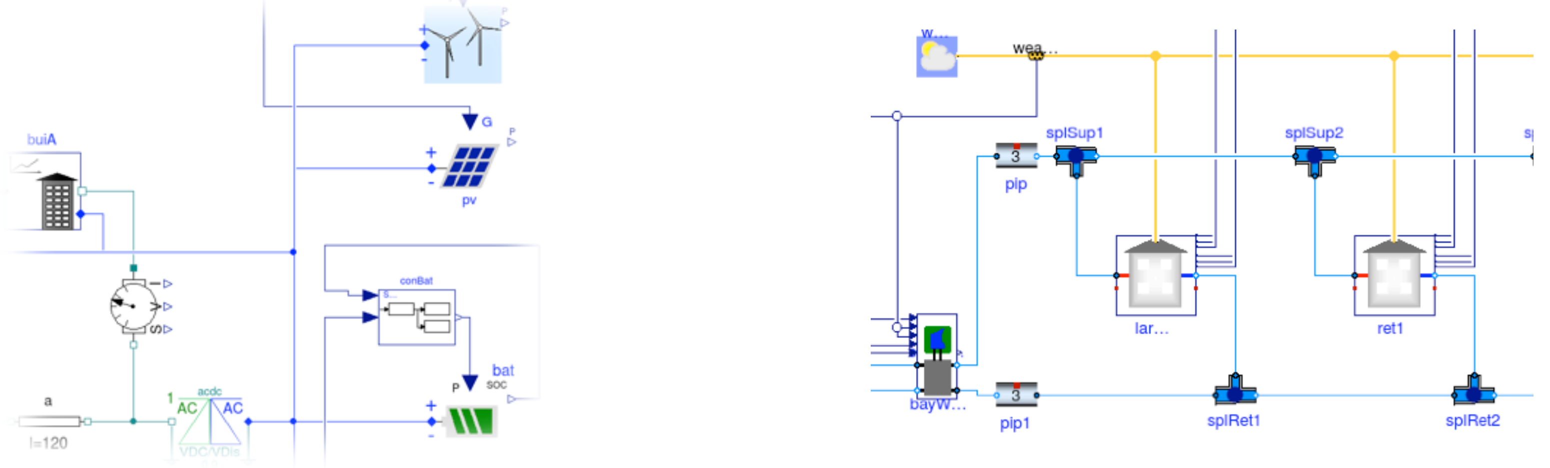
HVAC with realistic supervisory and local loop control

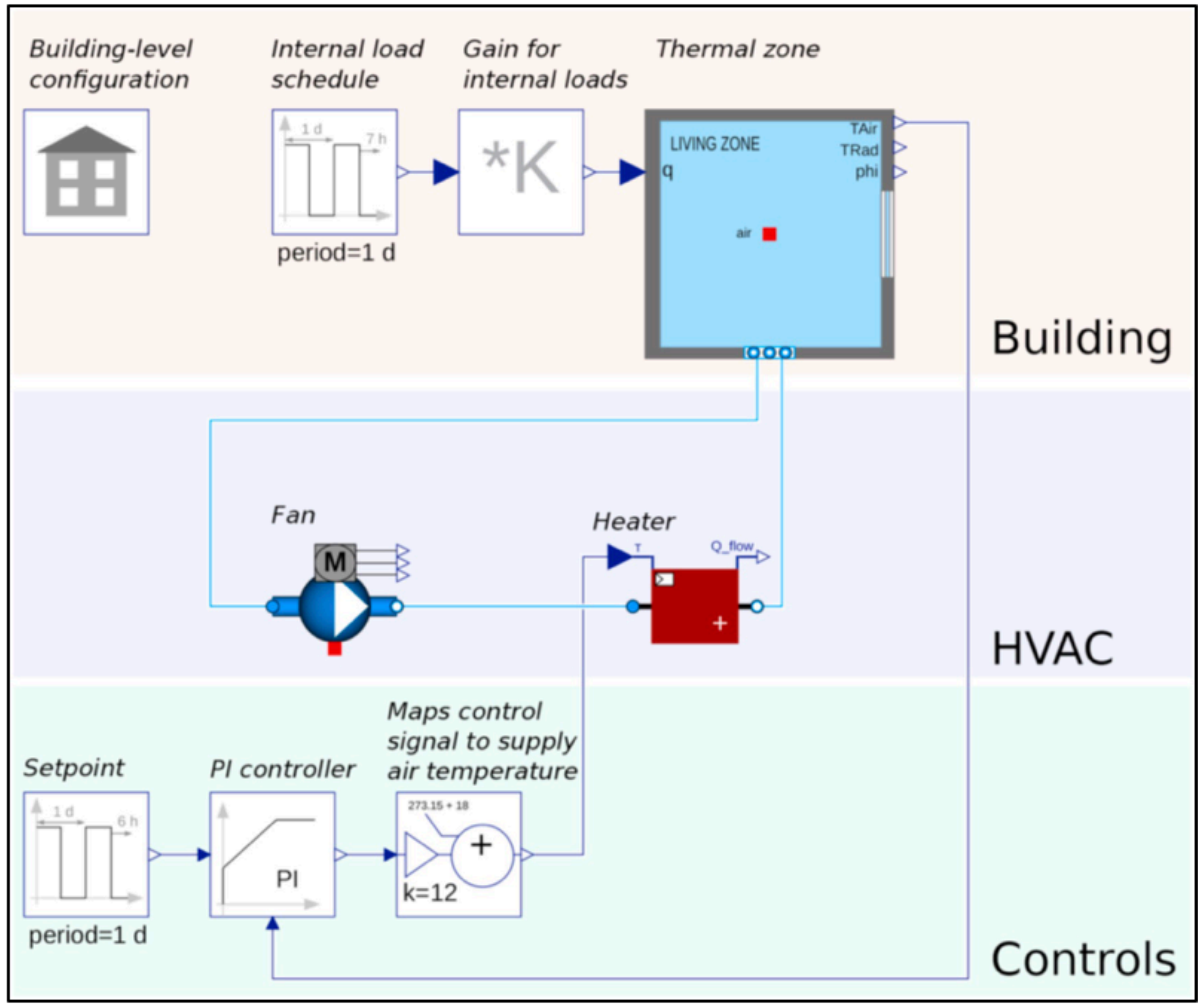


Building heat transfer, natural ventilation, and CFD



Fully coupled thermal, fluid flow, electrical and control simulation



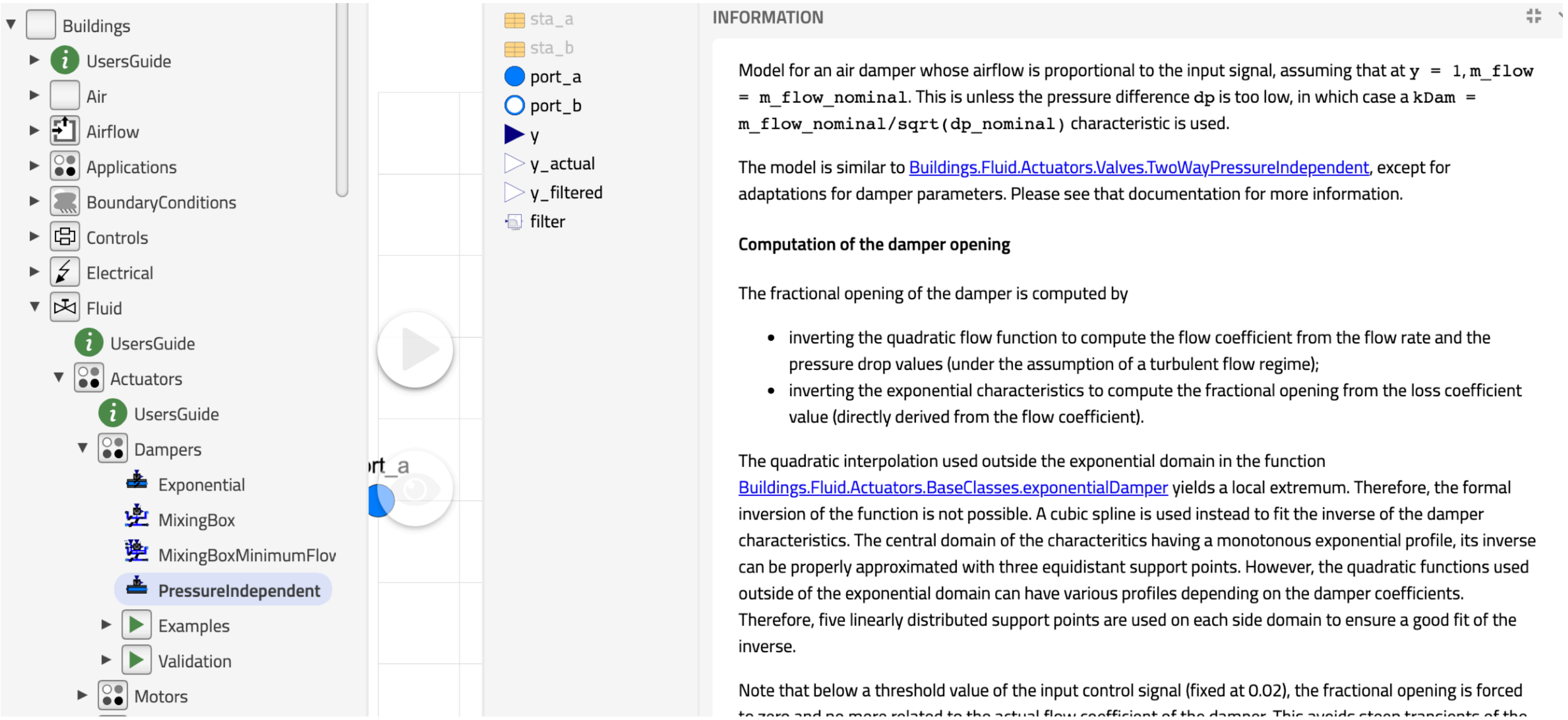


Graphical run-time coupling with Spawn of EnergyPlus

M. Wetter, W. Zuo, T.S. Nouidui, and X. Pang (2014). Modelica Buildings library. *Journal of Building Performance Simulation*, 7(4):253-270.

M. Wetter, K. Benne, A. Gautier, T.S. Nouidui, A. Ramle, A. Roth, H. Tummescheit, S. Mentzer and C. Winther (2020). Lifting the Garage Door on Spawn, an Open-Source BEM-Controls Engine. *Proc. of Building Performance Modeling Conference and SimBuild*, p. 518–525, Chicago, IL, USA, Sep 2020.

Documentation and distribution

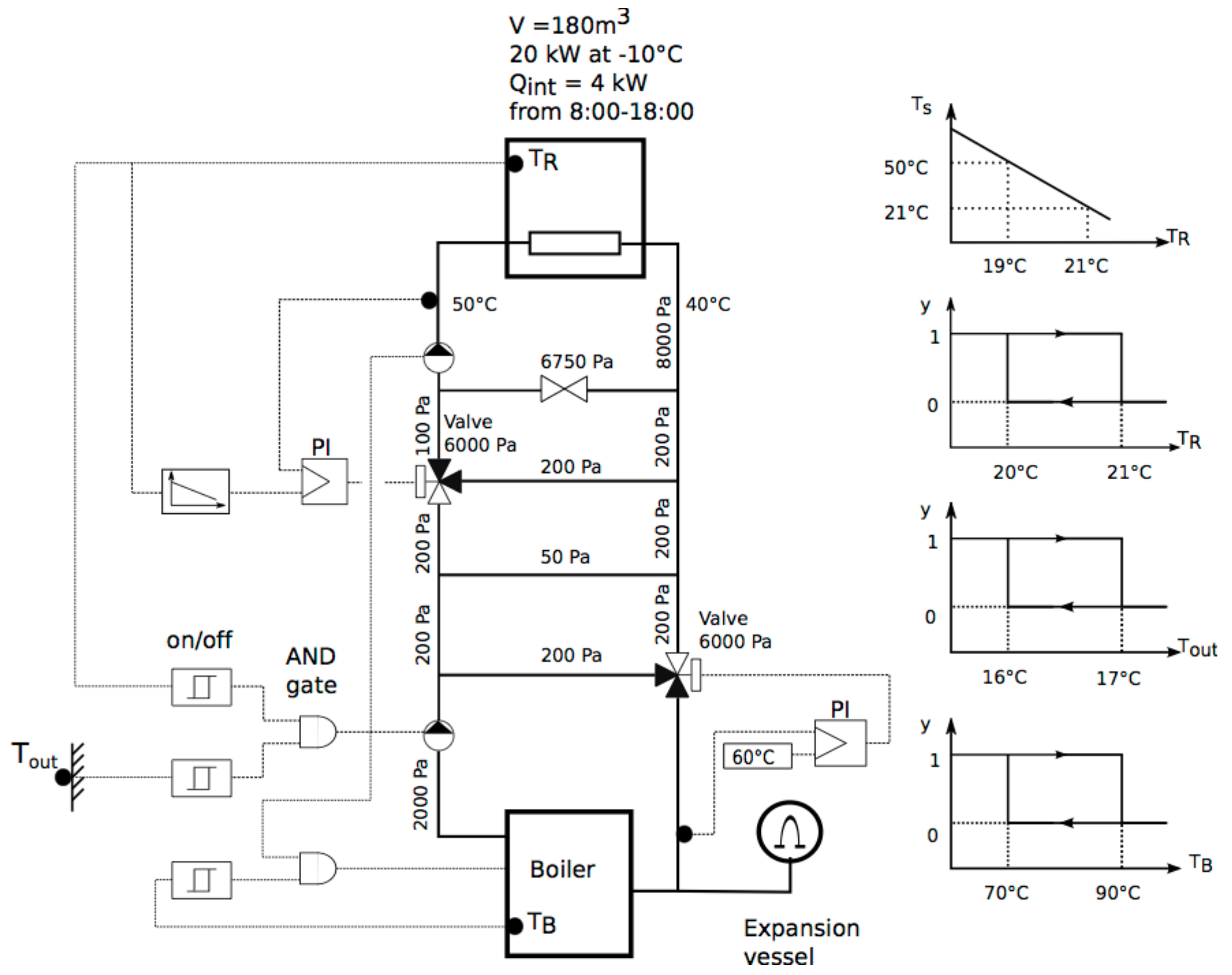


Documentation

- General user guide (getting started, best practice, developer instructions, ...).
- 26 user guides for individual packages.
- 3 tutorials with step-by-step instructions.
- All models contain an “info” section.
- Small test models for all classes, large test cases for “smoke tests,” and various validation cases.

Distribution

- For users: http://simulationresearch.lbl.gov/modelica
- For developers: https://github.com/lbl-srg/modelica-buildings



Modelica Buildings Library has comprehensive set of district energy models, enabling analysis of 1st to 5th generation systems

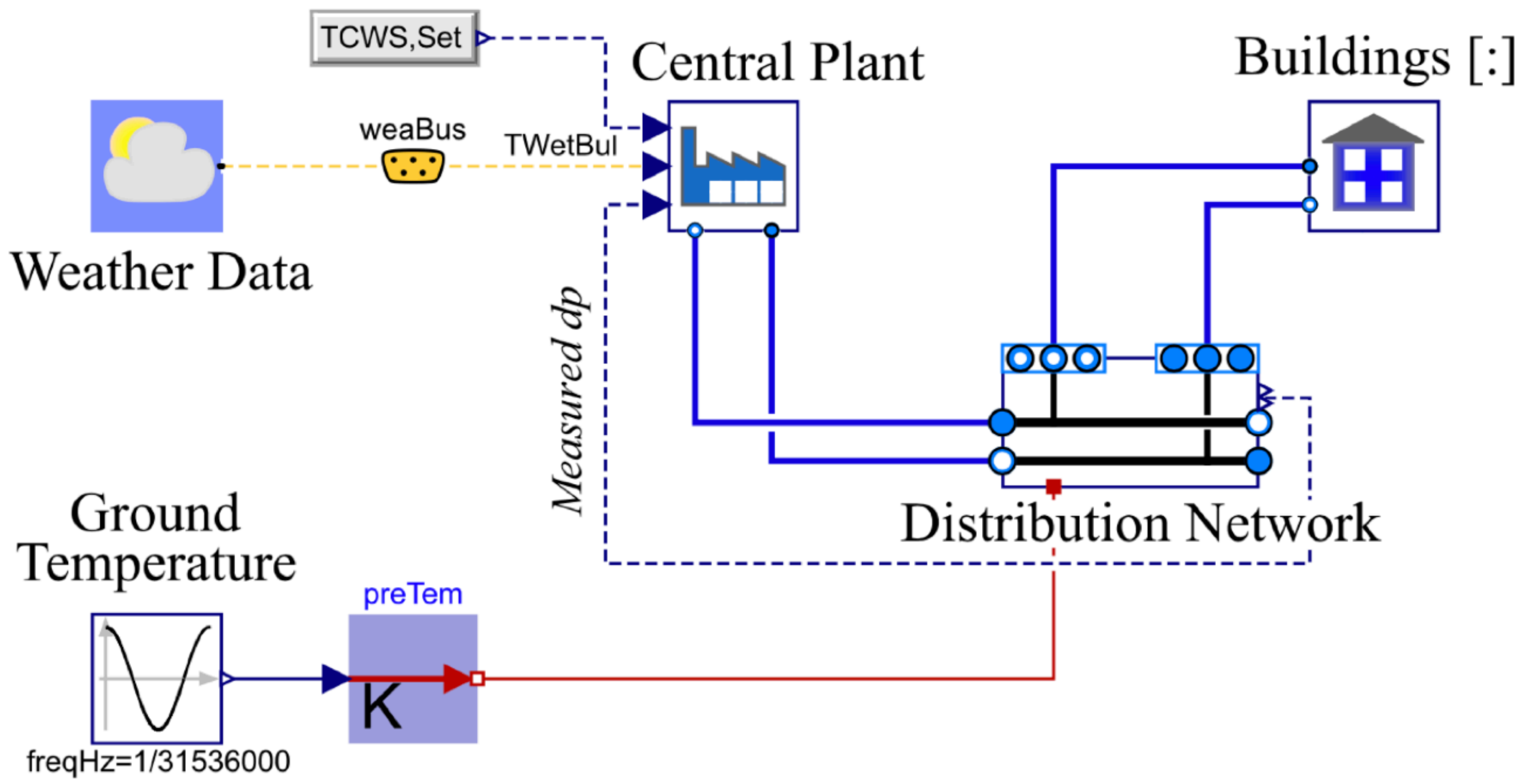
Large variety of thermal and electrical models exists
- 1st to 5th generation district heating and cooling
- AC and DC electrical models

Building Load
- Detailed EnergyPlus models
- Reduced order models
- Time series

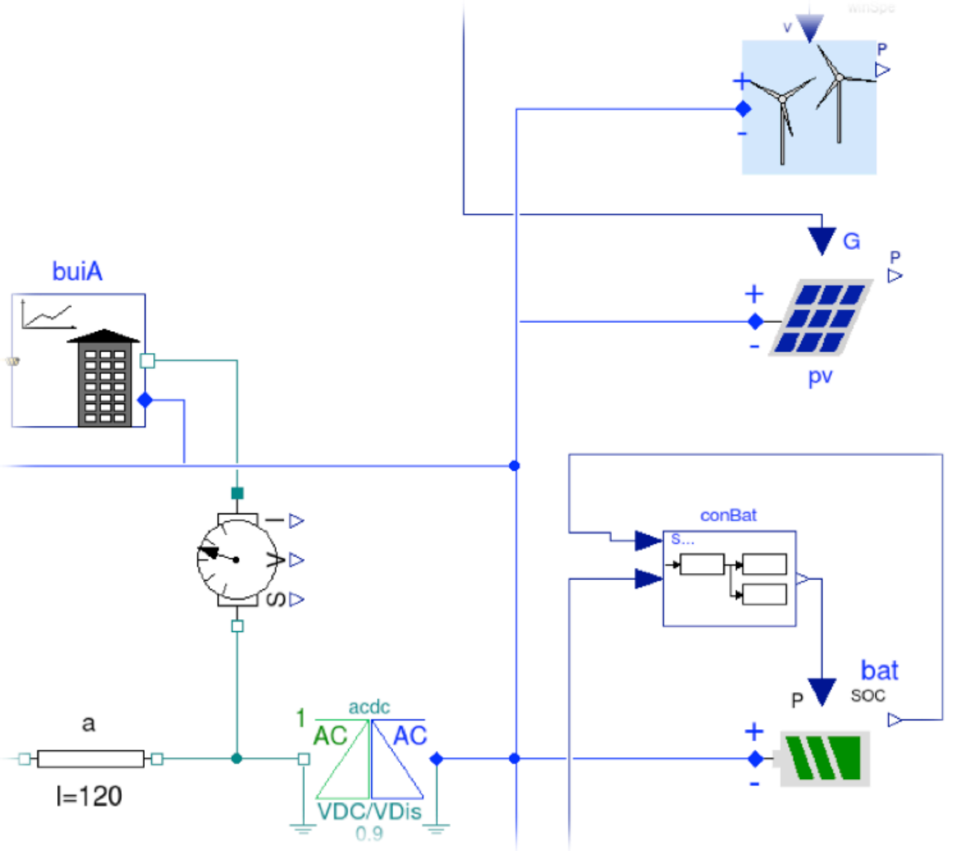
Energy Transfer Stations
- Indirect connection
- Indirect connection with booster heat pump
- Direct connection

Network Topology
- 1-Pipe
- 2-Pipe
- 4-Pipe
- Steam heating

Various storage technologies
- Borefields
- PCM
- Water or ice tanks
- Coupling with detailed geothermal simulators (TOUGH)

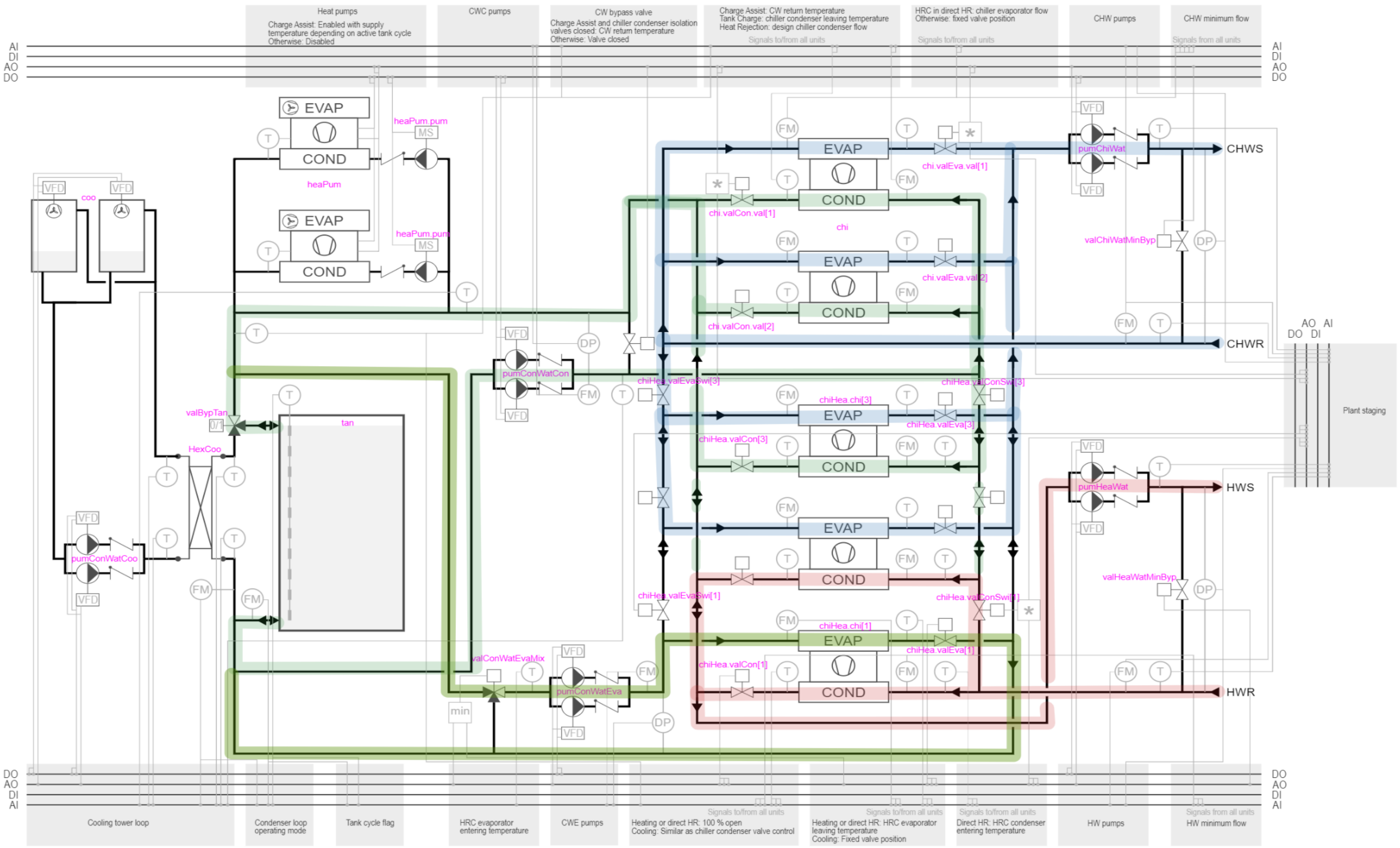


Library has preconfigured district energy systems.



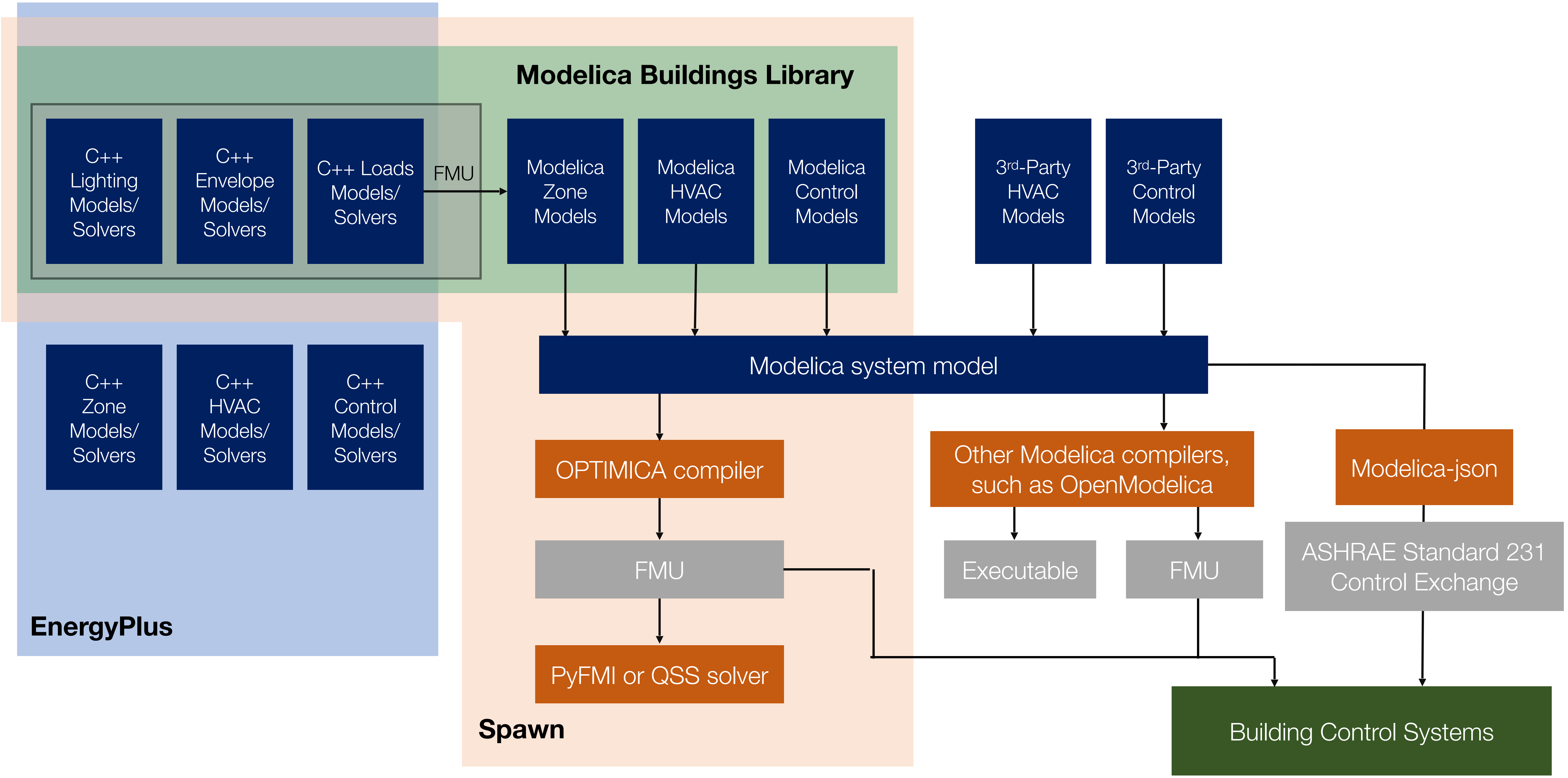
Models for electrical system simulation provide foundation for thermal, electrical, industrial and transportation sector integration.

Example of a energy transfer station

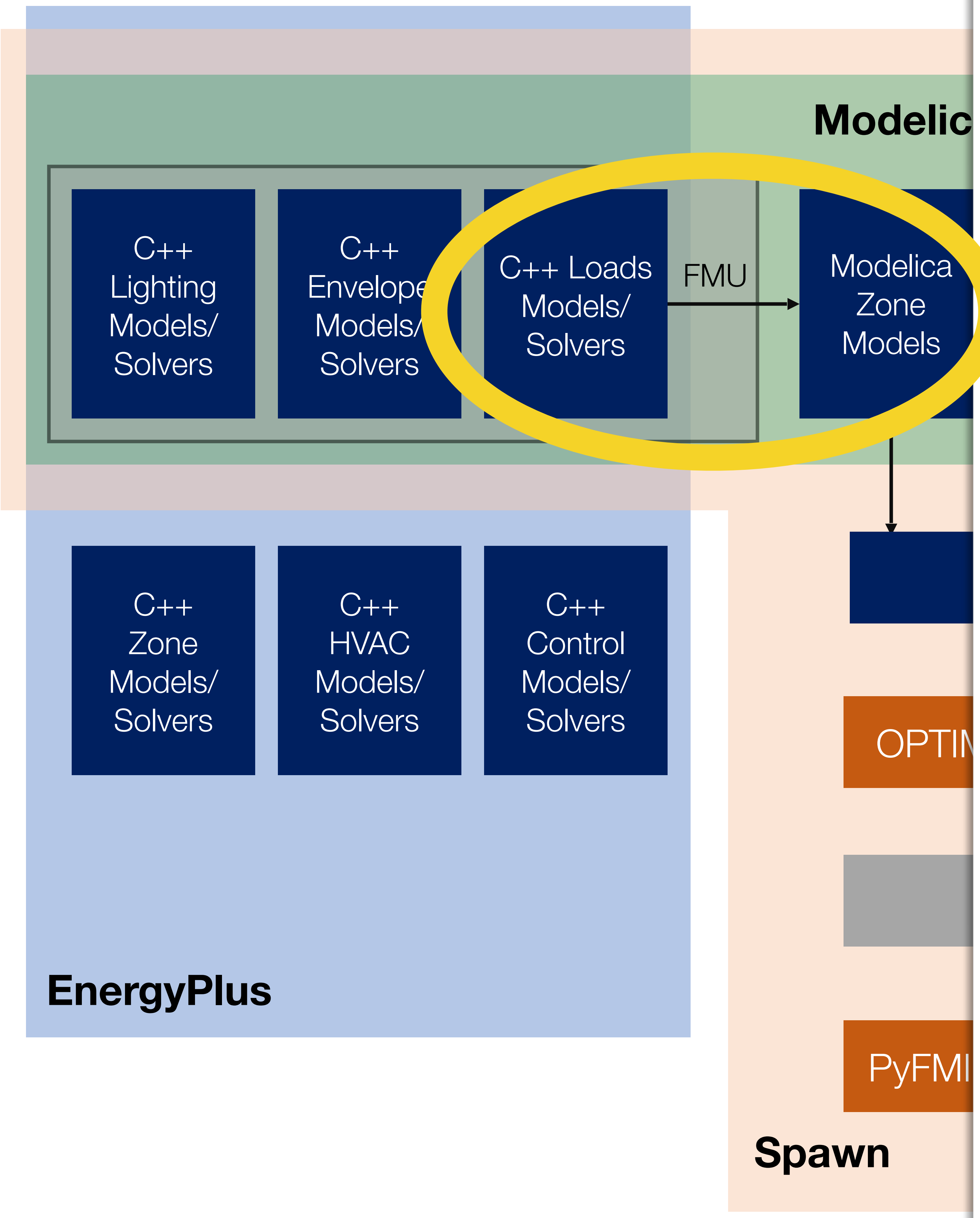


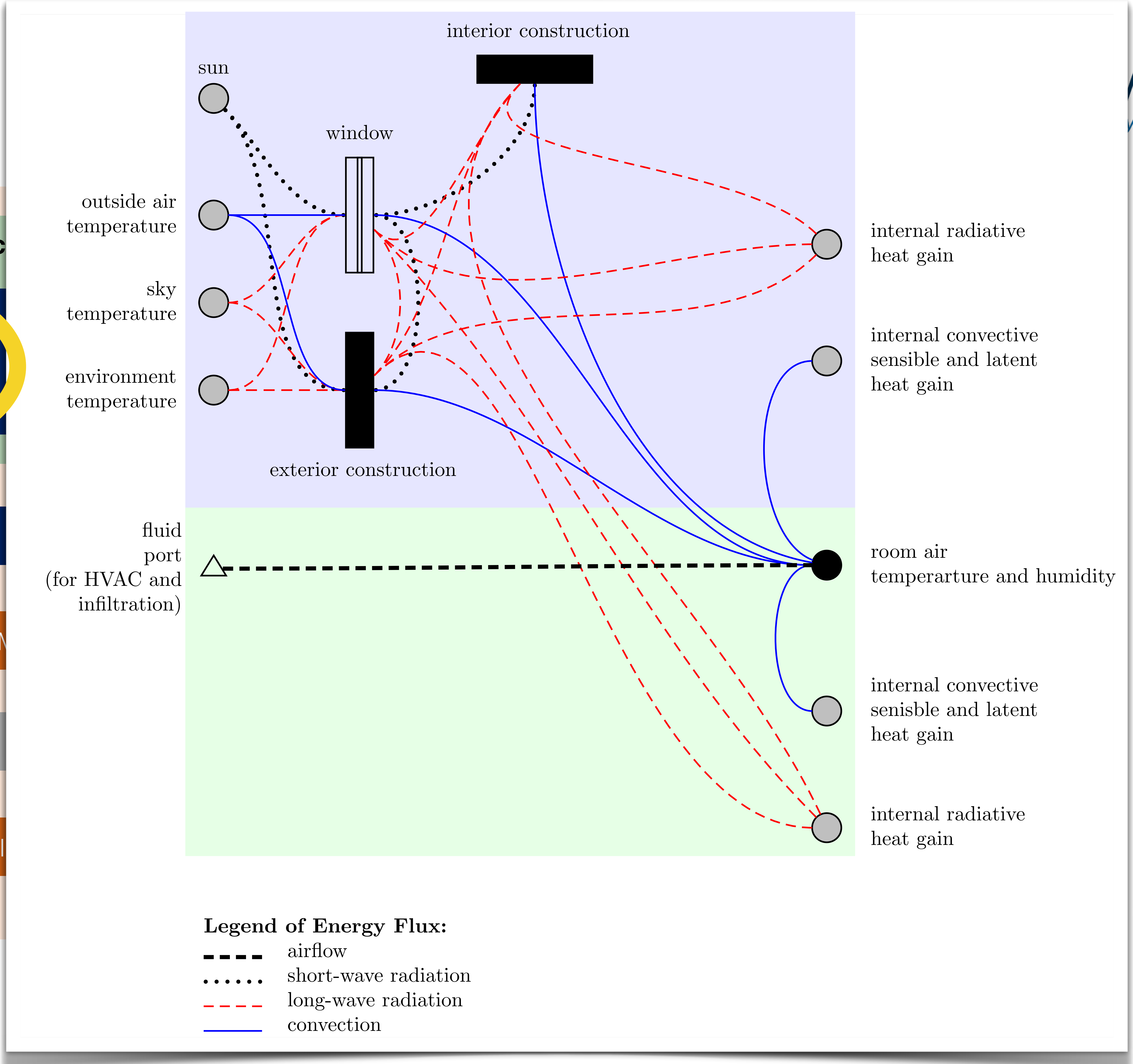
Example for an all-electric plant (model: Buildings.Experimental.DHC.Plants.Combined.AllElectricCWStorage)

Spawn allows use of EnergyPlus envelope model with Modelica HVAC and controls via FMI Standard



Spawn allows use of EnergyPlus envelope model with Modelica HVAC and controls via FMI Standard



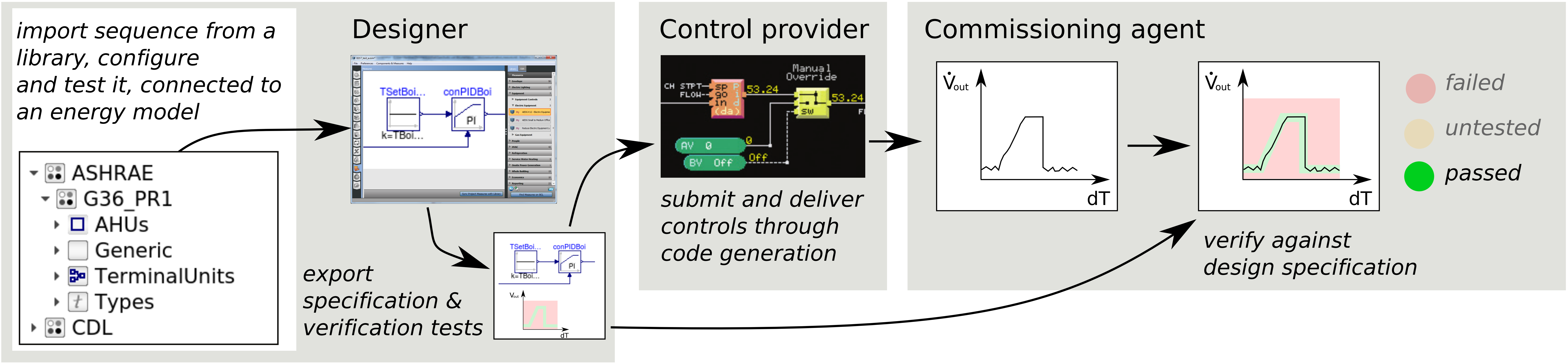


OpenBuildingControl digitizes the control delivery process based on the ASHRAE Standard 231P for which Buildings.Controls.OBC.CDL has the reference implementation

Sequence selection and performance assessment

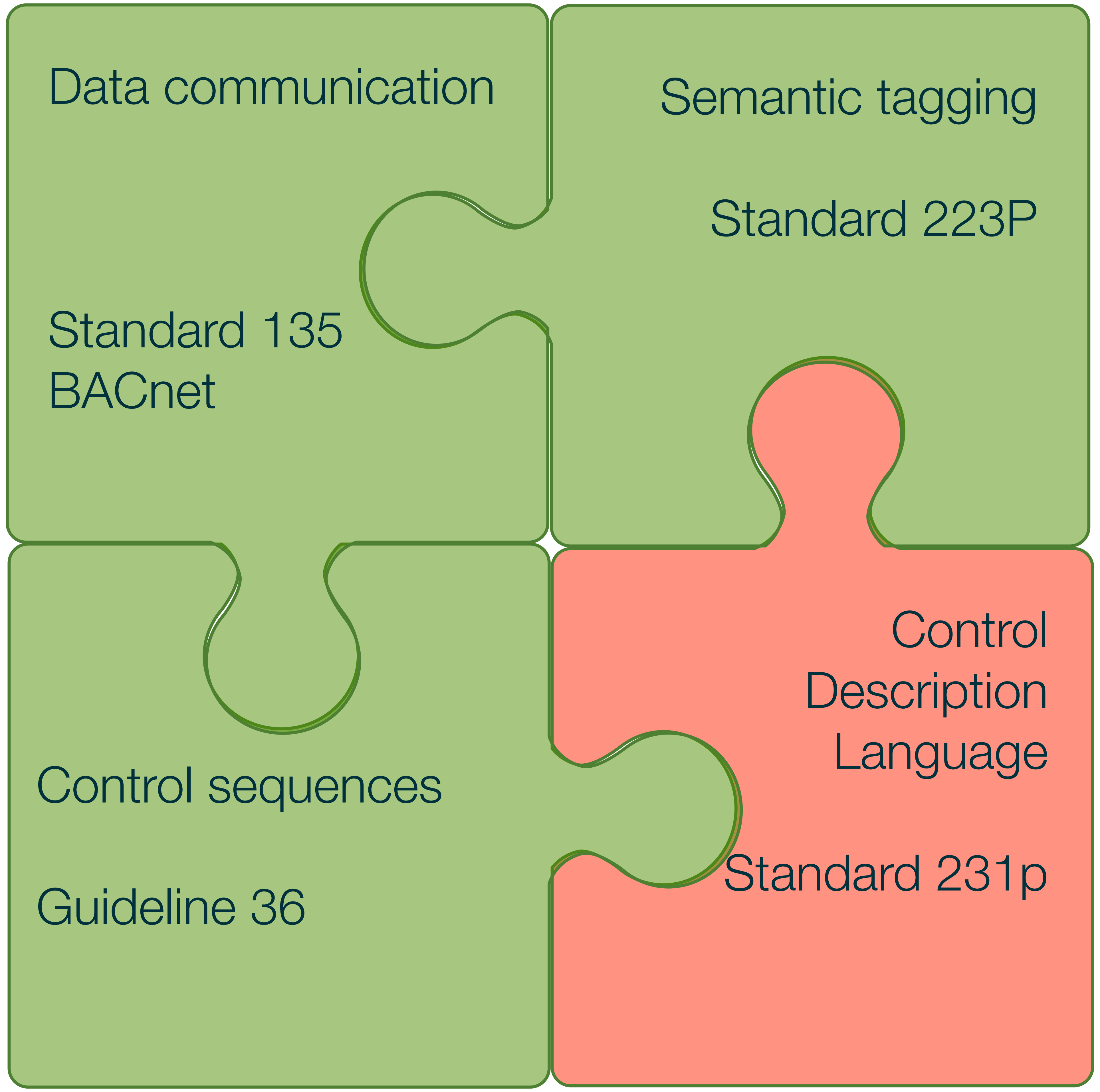
Machine-to-machine translation

Formal end-to-end verification



Michael Wetter, Paul Ehrlich, Antoine Gautier, Milica Grahovac, Philip Haves, Jianjun Hu, Anand Prakash, Dave Robin and Kun Zhang.
OpenBuildingControl: Digitizing the control delivery from building energy modeling to specification, implementation and formal verification.
Energy, Volume 238, Part A, January 2022.

What gap does CDL address?



Implementation

Name	Description
Constants	Package with constants
Conversions	Package with blocks for type conversion
Discrete	Package with discrete blocks
Integers	Package with blocks for integer variables
Logical	Package with logical blocks
Psychrometrics	Package with psychrometric blocks
Reals	Package with blocks for continuous variables
Routing	Package with blocks that combine and extract signals
Utilities	Package with utility functions
Types	Package with type definitions
Interfaces	Package with connectors for input and output signals

Elementary blocks

Composition rules,
see https://obc.lbl.gov/specification/cdl.html

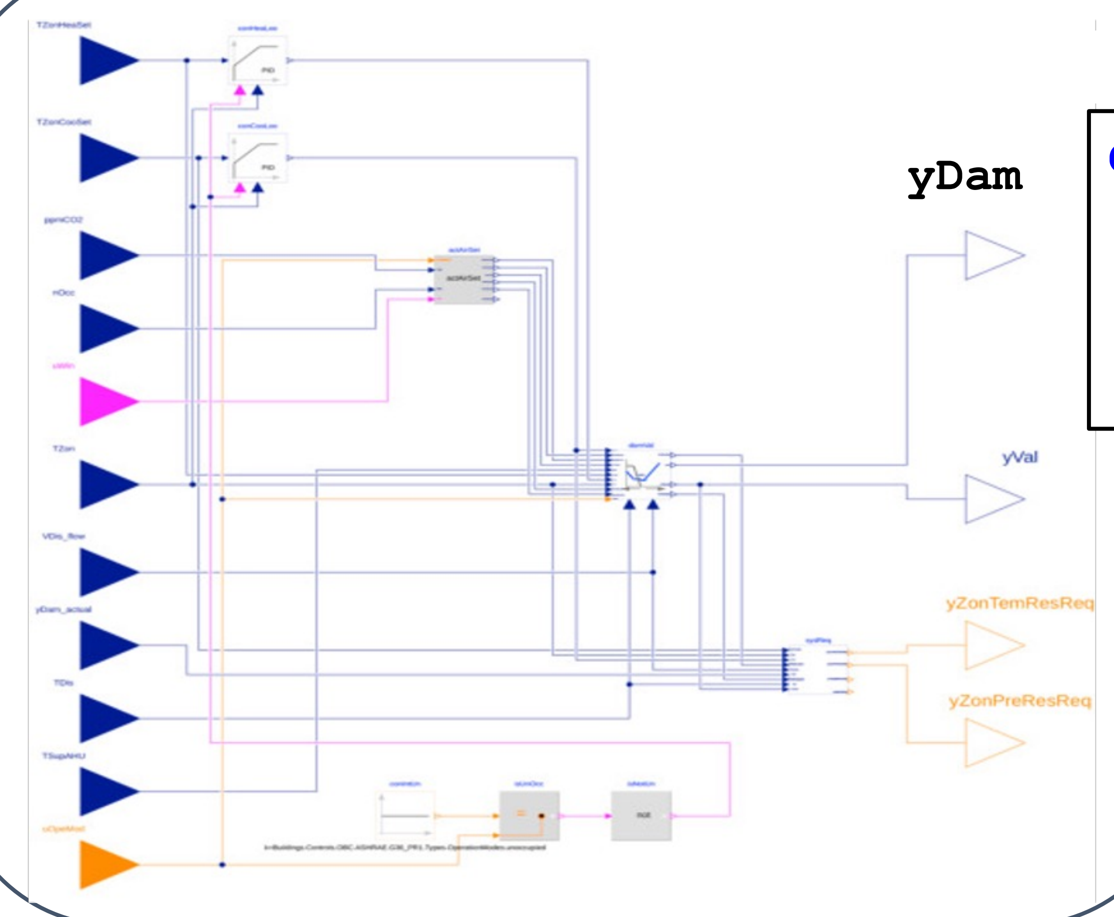
ASHRAE Standard 231P

Name	Description
UsersGuide	User's Guide
ASHRAE	Package with control sequences from ASHRAE projects
CDL	Package with blocks, examples and validation tests for control description language
OutdoorLights	Package with controllers for outdoor lights
RadiantSystems	Package with controllers for radiant heating and cooling systems
Shade	Package with controllers for shades
UnitConversions	Package with blocks for unit conversion
Utilities	Package with utility functions

Repository of pre-configured control logic

Combining control logic and semantic models to digitalized control delivery

Generic VAV terminal box control logic (CDL)



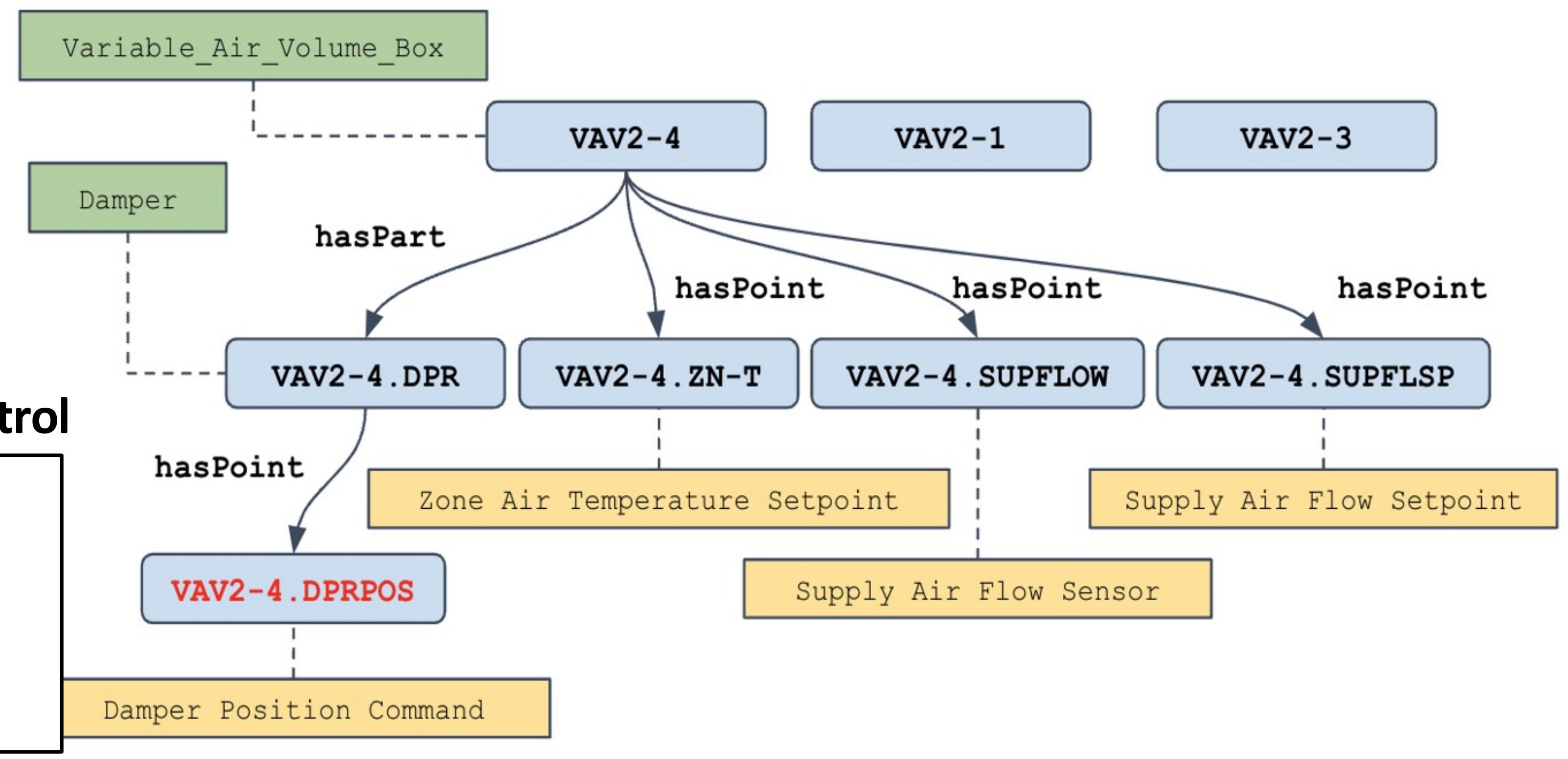
CDL for yDam VAV Damper Position Control

```
CDL.Interfaces.RealOutput yDam (
  final min=0, final max=1, final unit="1")
  "Signal for VAV damper"
  annotation (__semantic(standard="brick"
    "a brick:Damper_Command ."));
```

brick for VAV2-4.DPRPOS Damper Position Control

```
:VAV2-4 a brick:VAV;
   brick:hasPart :VAV2-4.DPR
:VAV2-4.DPRPOS a brick:Damper_Command;
   brick:isPointOf :VAV2-4.DPR
   bacnet:object-name "DMP_CM_2-4" .
```

Building-specific semantic model (Brick)



Brick

Modelica

1

SPARQL query for finding VAV boxes in Brick model

```
SELECT ?vav WHERE {
   ?vav a brick:VAV ;
}
Result: {"VAV2-4", "VAV2-1", "VAV2-3"}
```

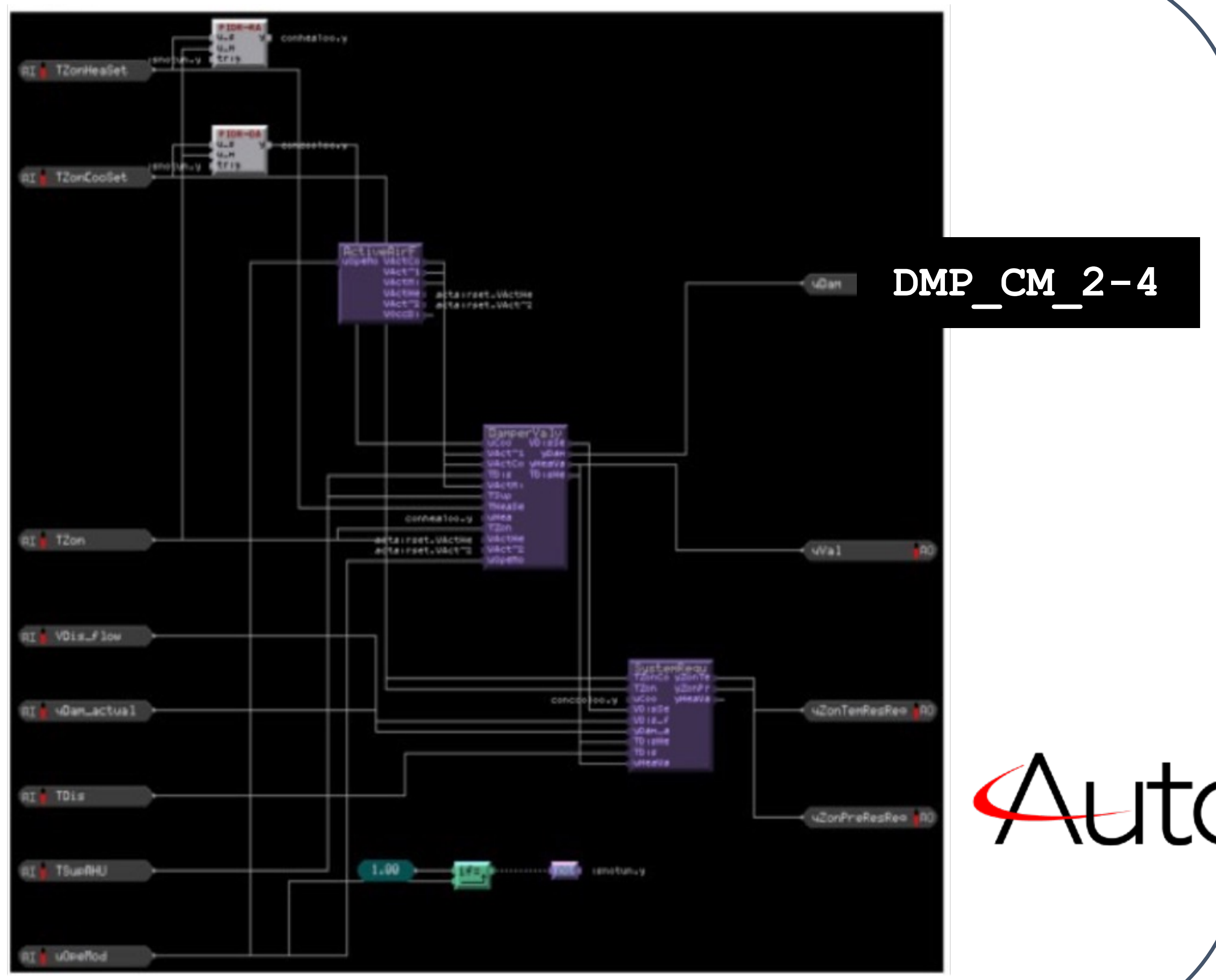
2

SPARQL query for finding BACnet point name of VAV2-4 Damper Position control

```
SELECT ?dprpos ?point WHERE {
   ?dprpos a brick:Damper_Command ;
      brick:isPointOf+ :VAV2-4 ;
      bacnet:object-name ?point .
}
Result: {"VAV2-4.DPRPOS", "DMP_CM_2-4"}
```

3

Building-specific VAV box control logic (ALC)



Automated Logic

Amir Roth, Michael Wetter, Kyle Benne, David Blum, Yan Chen, Gabriel Fierro, Marco Pritoni, Avijit Saha and Draguna Vrabie.
Towards Digital and Performance-Based Supervisory HVAC Control Delivery.
ACEEE Summer Study on Energy Efficiency in Buildings, p. 3-528--3-543, Pacific Grove, CA, August, 2022.

Discussion