ALL-IN-ONE MODELING OF HEAT PUMP BASED PROSUMER STATIONS THROUGH MODELICA BUILDINGS LIBRARY v9.1.0 UNDER OPENMODELICA ENVIRONMENT

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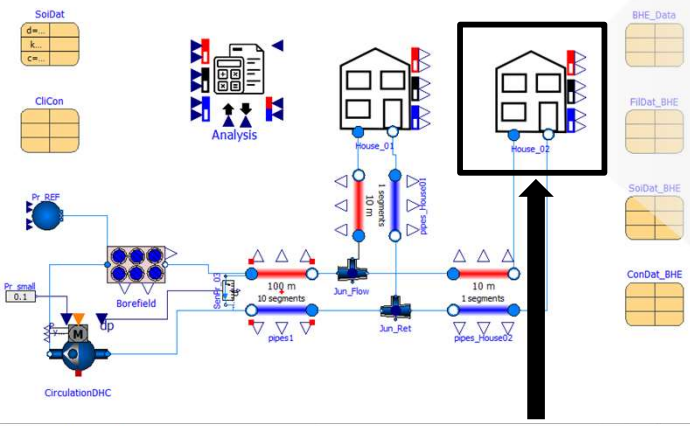
INTRODUCTION

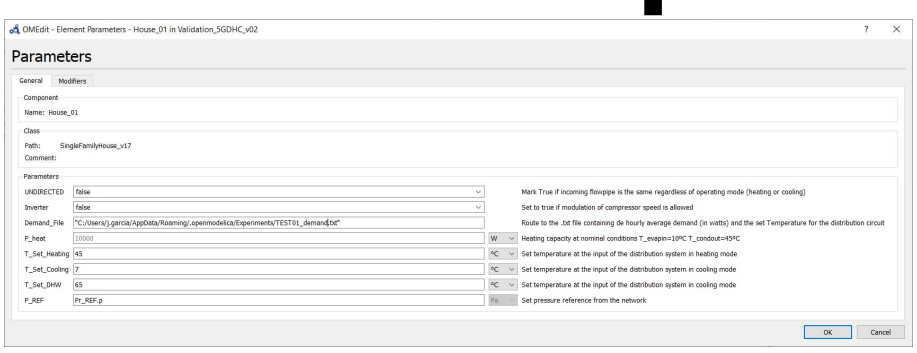
Modelica language provides unsurpassed capabilities for dynamic modeling of physical systems. The open-source, Modelica-based libraries developed from the outcomes of the IBPSA Project 1 (formerly IEA-DHC Annex 60) are among the most widely used software tools nowadays. In particular, the Modelica Buildings Library (MBL) developed by the Lawrence-Berkeley National Laboratory (California, US) contains several accurate physical models of water-to-water heat pumps (HPs).

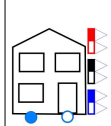
This work presents a simple model of a house, understood as a prosumer substation in the context of 5th generation district heating and cooling (5GDHC) networks. The input is just a dataset of hourly-resolved demand (or average load). The architecture of the model is conceived to admit internal heat recovery and to be connected either to a directed or undirected 5GDHC network. The main goal is to provide a simplistic way of connecting multiple and diverse demand profiles using just a single model of a prosumer substation, to illustrate the benefits of 5GDHC networks in front of individualized HP installations.

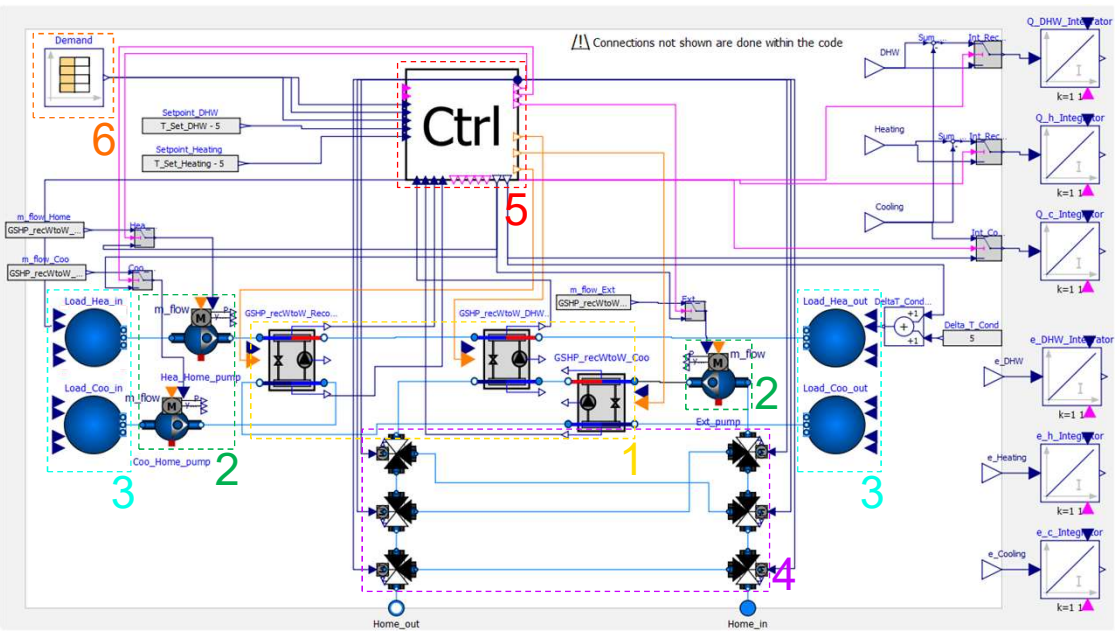
MODEL PRESENTATION

- Coding language: Modelica.
- Environment: OpenModelica (OMEdit v 1.19.2).
- Libraries:
  - Modelica Standard Library v 4.0.0 (Modelica Association)(1).
  - Modelica Buildings Library v 9.1.0 (LBNL-California-USA)(2).

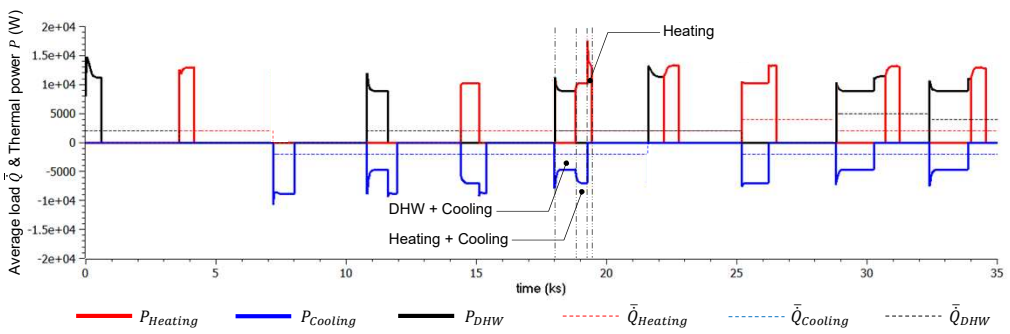




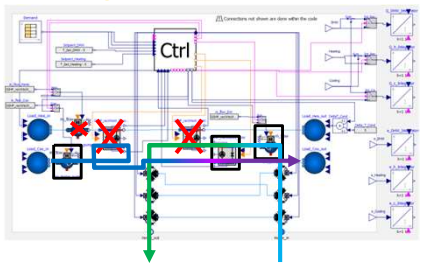
	INPUTS	OUTPUTS	UNDERLAYING PRINCIPLE
	- Hourly average load (W) (.txt file) concerning heating, cooling and DHW. - $T_{set}^{Heating}, T_{set}^{Cooling}, T_{set}^{DHW}$ - Nominal heating power. - Directed/Undirected network.	- Heating, cooling and DHW production - Electrical power consumption (includes circulation pumps)	Reciprocating water-to-water heat pump operated with ON/OFF cycles. Internal heat recovery is considered.



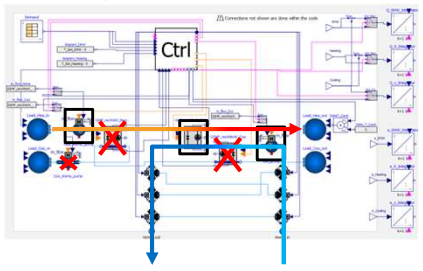
1. `Buildings.Fluid.HeatPumps.ReciprocatingWaterToWater`: The heat pump model is represented by a set of 3 identical components, but only one operating each cycle, depending on the operating mode.
2. `Buildings.Fluid.Movers.FlowControlled_m_flow`: The internal and external circulating pumps are represented by 3 identical components. Two of them are always operative, circulating water through the condenser and the evaporator sides of the heat pump. The mass flow is pre-calculated from the nominal heat capacity of the heat pump and the imposed ΔT (+5ºC at the condenser and -3ºC at the evaporator).
3. `Buildings.Fluid.Sources.Boundary_pT`: The load side is represented by boundaries of prescribed pressure. These elements impose the temperature setpoint for heating and DHW at the condenser (under heating mode) and for cooling at the evaporator (under cooling mode).
4. `Buildings.Fluid.Actuators.Valves.ThreeWayLinear`: This set of 3-way valves allows the prosumer station to choose between unidirectional or bidirectional mass flow in the network. It also procures a bypass to the network flow whenever the load at the building is null.
5. `Control_logic` (own elaboration): A set of logical algorithms are implemented to operate the heat pumps according to the demand. DHW production is prioritized over heating, and heat recovery is prioritized over just heating/DHW or cooling modes. The heat pump is turned ON at full power until the demand of that hour is met.
6. `Modelica.Blocks.Sources.CombiTimeTable`: The yearly demand is loaded as a .txt file with hourly values of the DHW, heating and cooling demands (kWh).



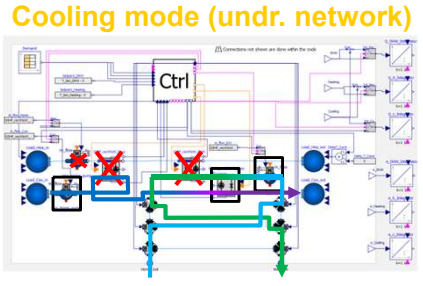
Cooling mode



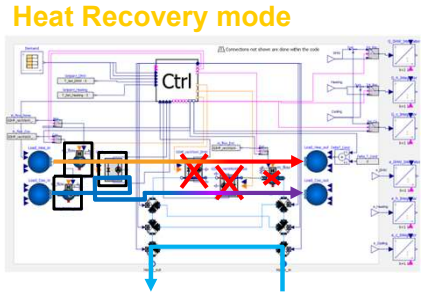
Heating/DHW mode



Cooling mode (undr. network)



Heat Recovery mode



Illustrative color scale for water temperature

cool ← → warm

FINAL REMARKS

- Conceptually simple and robust. Fully open-source tool.
- Allows to compare individual vs. networked GSHPs, influence of pipe-insultation in the network, climate and ground characteristics, load aggregation, extension of the grid, etc.
- Useful for design, feasibility studies, validation of static models, digital twins.

REFERENCES

(1) https://github.com/modelica/ModelicaStandardLibrary
(2) https://simulationresearch.lbl.gov/modelica/

ACKNOWLEDGEMENTS

This work has been partially supported by the AGAUR grant for Industry Doctorate Research 2021-DI-0072