KU LEUVEN

Demonstration project ‘De Schipjes’: a zero-fossil-fuel energy concept in the historic city centre of Bruges

18/10/2021

Jelger Jansen, KU Leuven, Thermal System Simulations (The SySi)

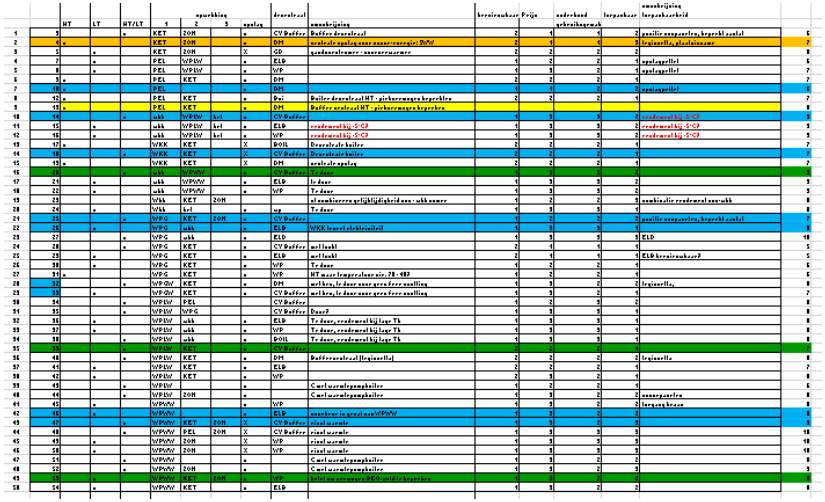
Almshouses ‘De Schipjes’

- Social housing neighborhood
- VLAIO demonstration project
- Renovate with focus on energetic and ecological aspects
- Classified as heritage

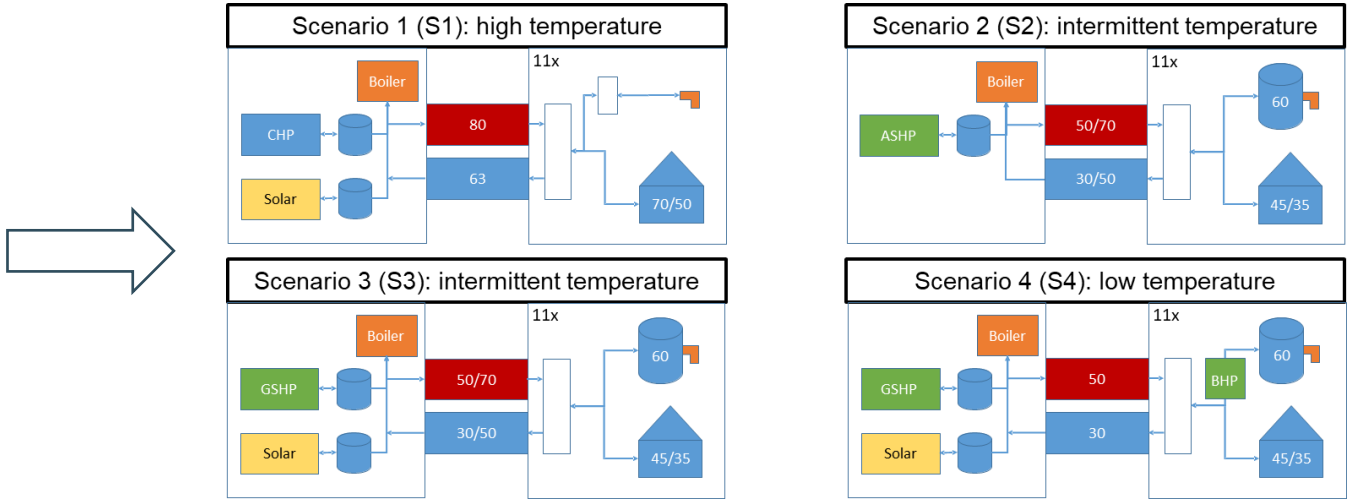
Almshouses ‘De Schipjes’

1. Retrofit buildings → lower heat demand

2. District heating (DH) network

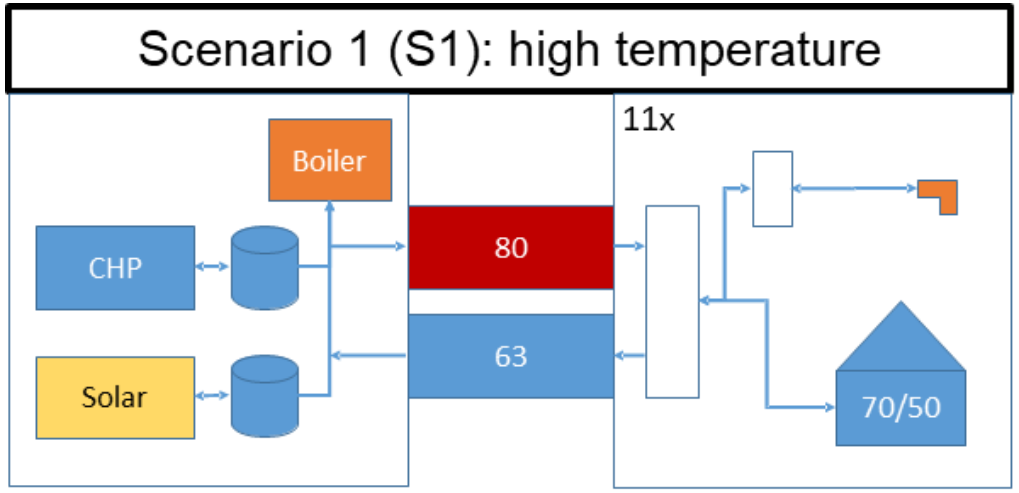


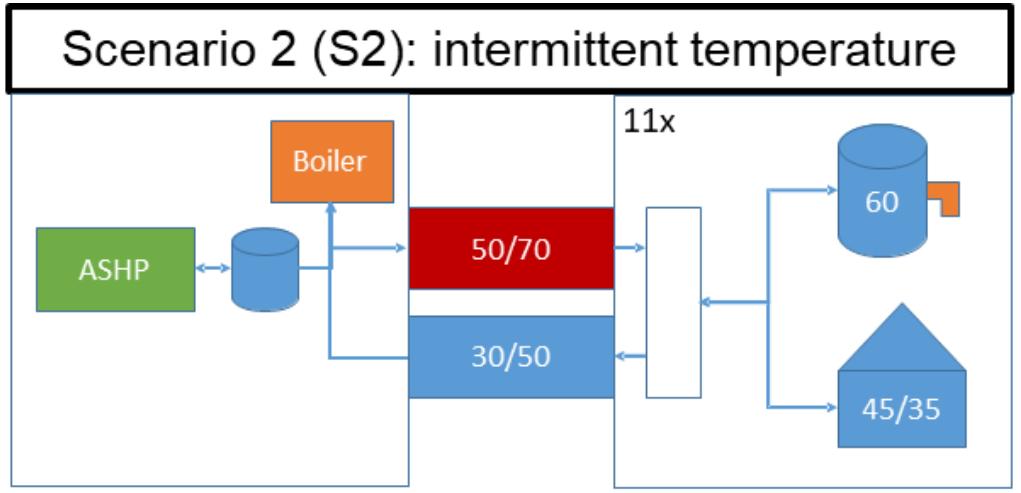
Experience-based longlist

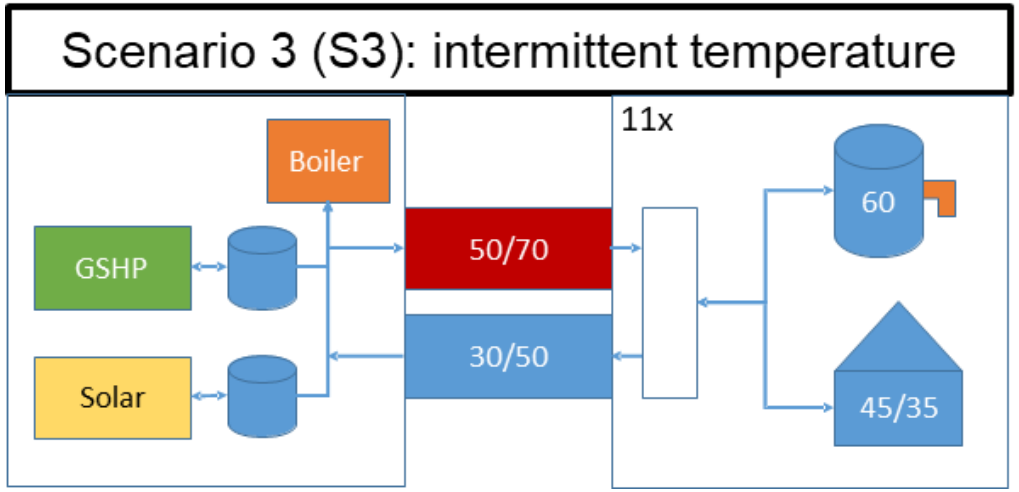


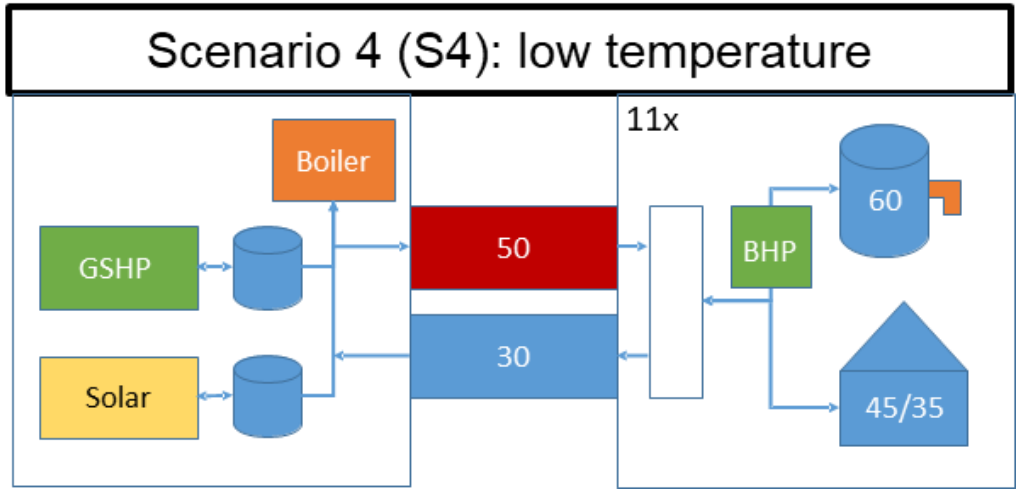
4 promising scenarios

Scenario analysis

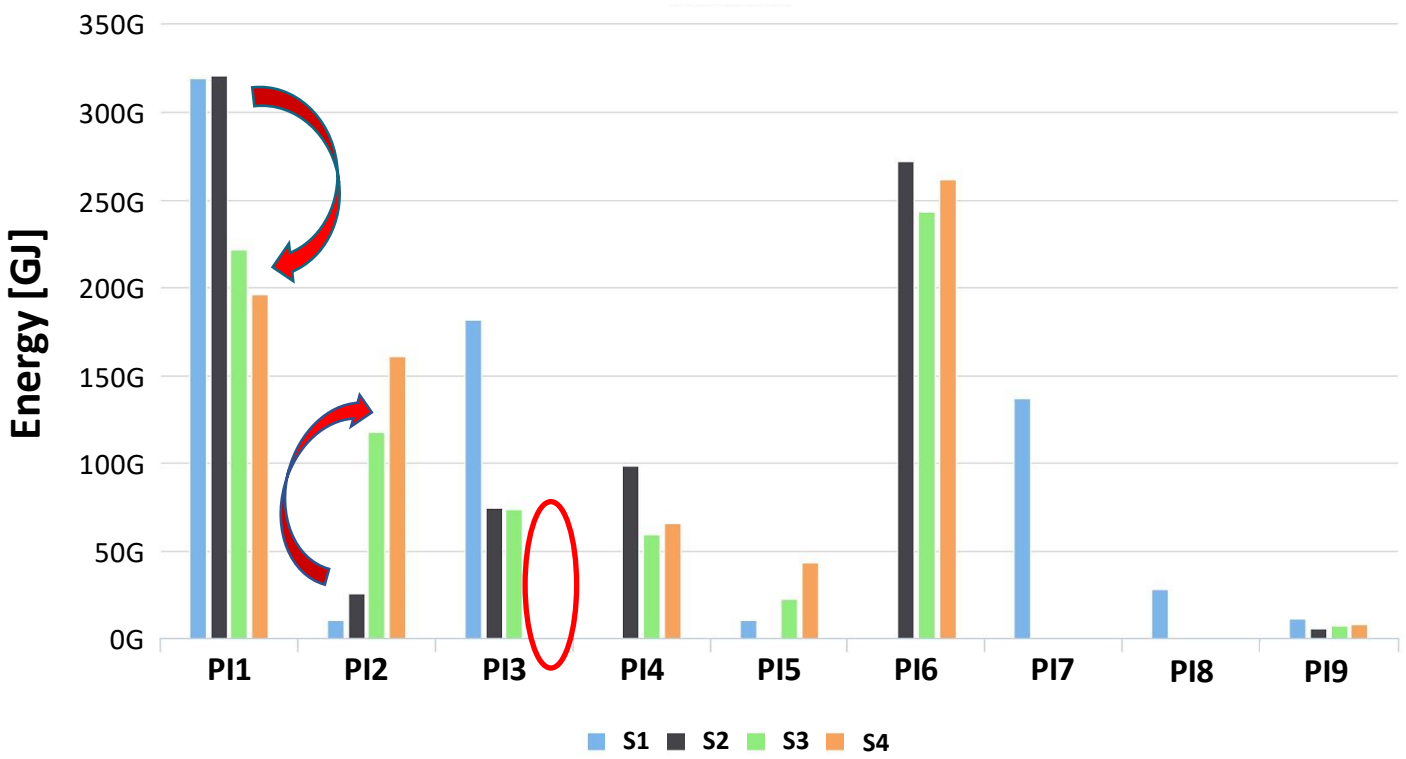








Scenario analysis



Performance indicators (PIs)

PI1: Primary energy use

PI2: Renewable energy use

PI3: Boiler fuel consumption

PI4: Heat pump electricity consumption

PI5: Solar collector heat production

PI6: Heat pump heat production

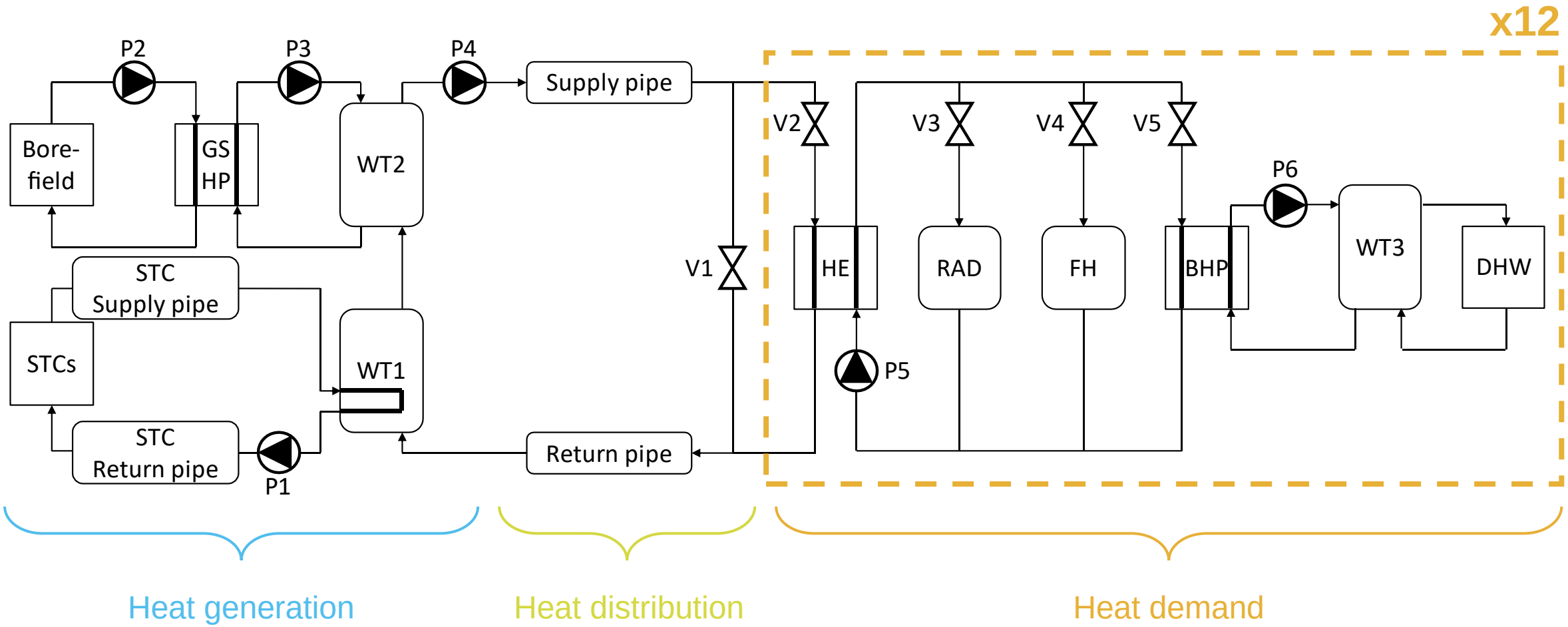
PI7: CHP fuel consumption

PI8: CHP electricity production

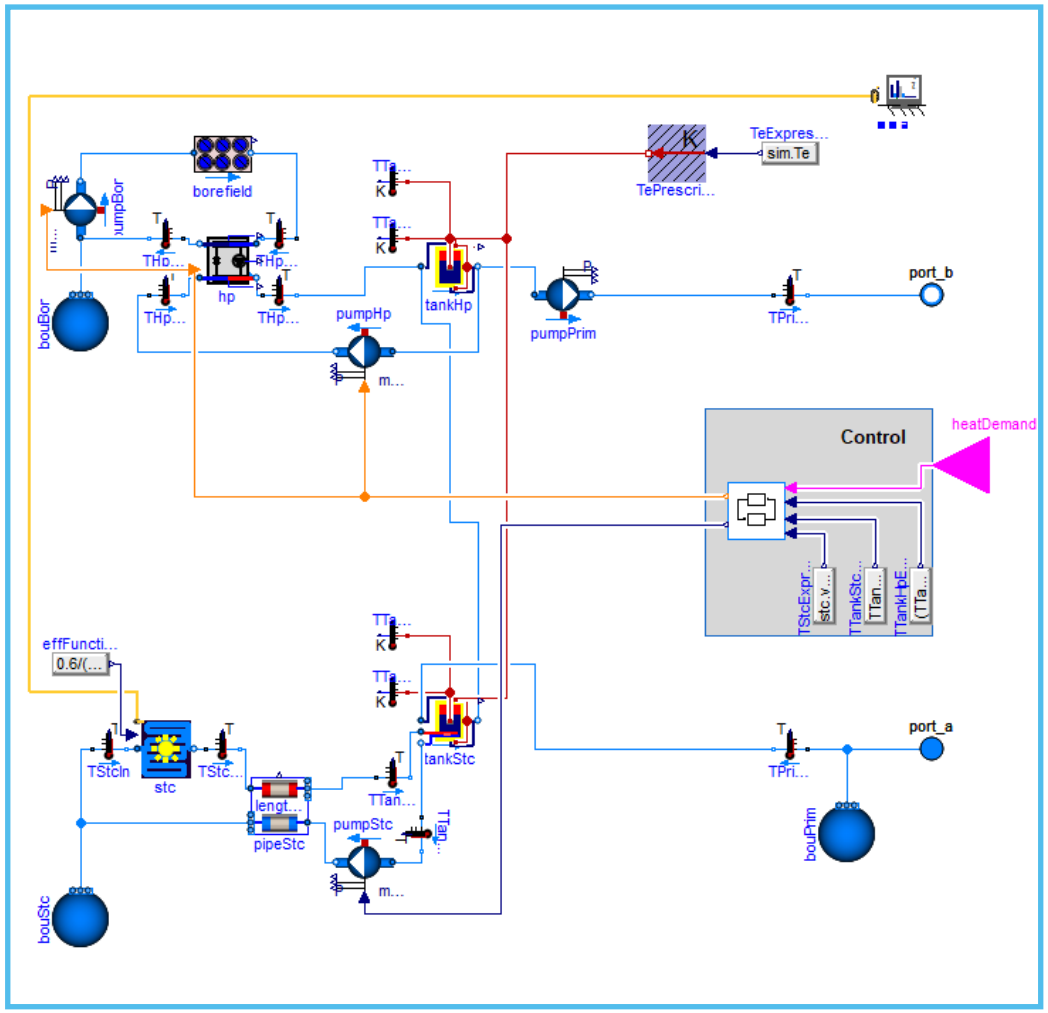
PI9: Storage tank heat losses

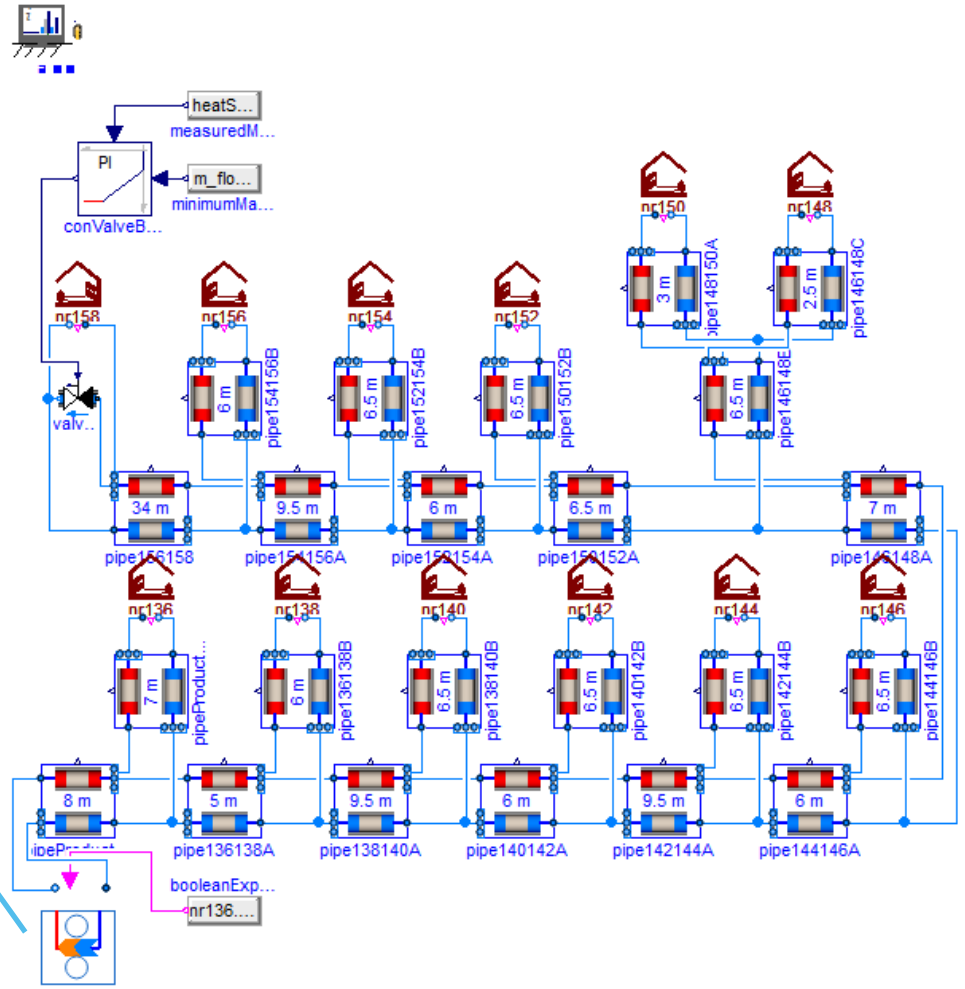
➔ Scenario 4 – low-temperature DH network

District heating network – hydraulic scheme

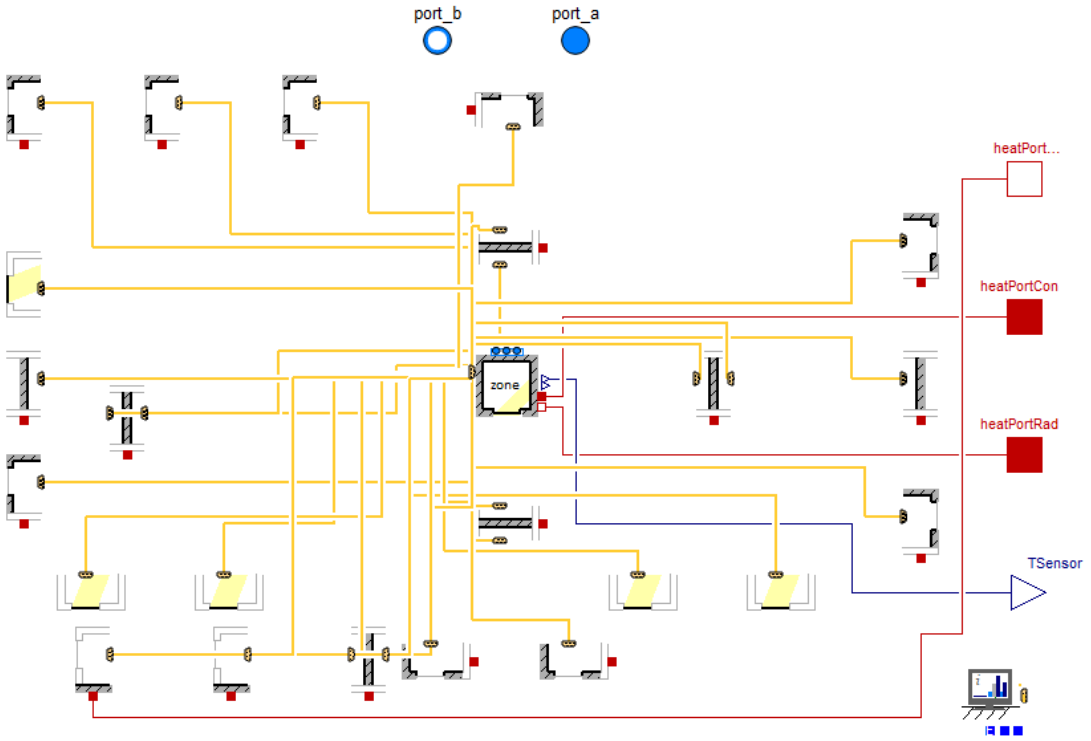


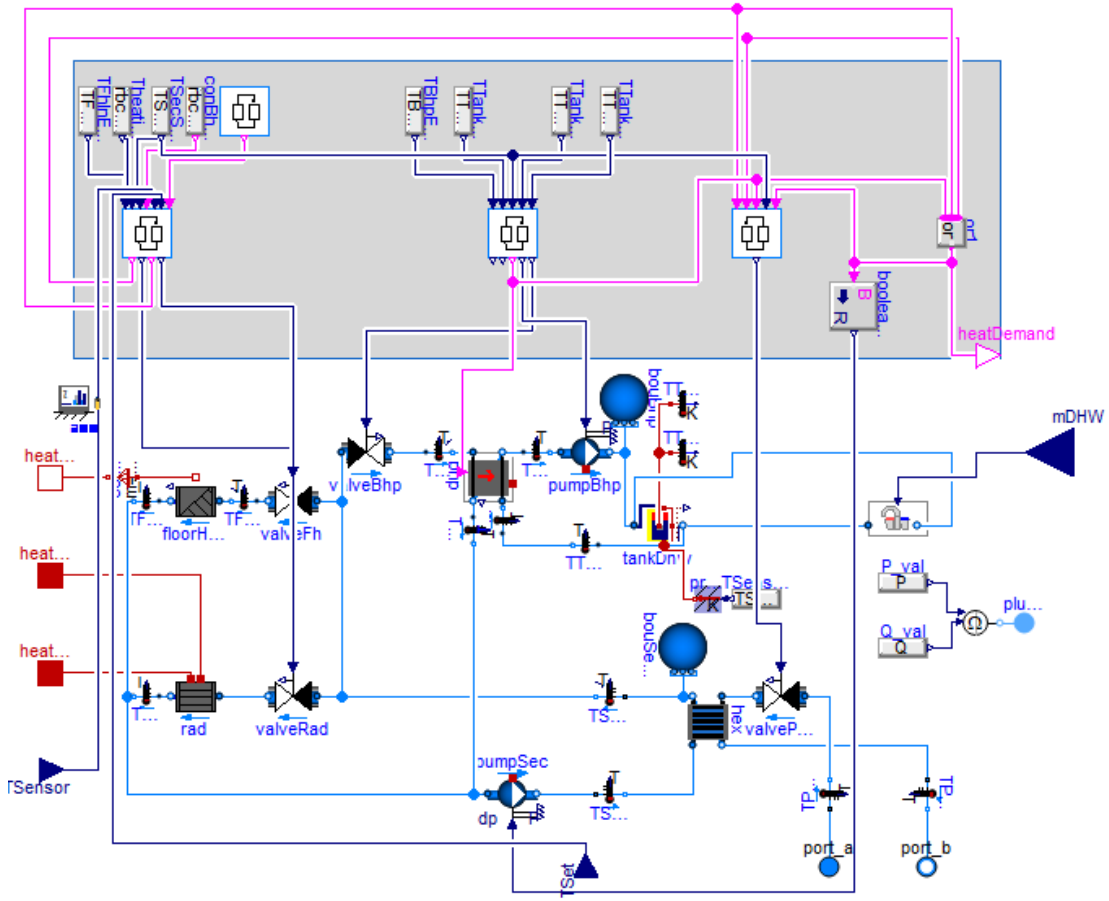
Modelica model – heat generation + distribution





Modelica model – heat demand



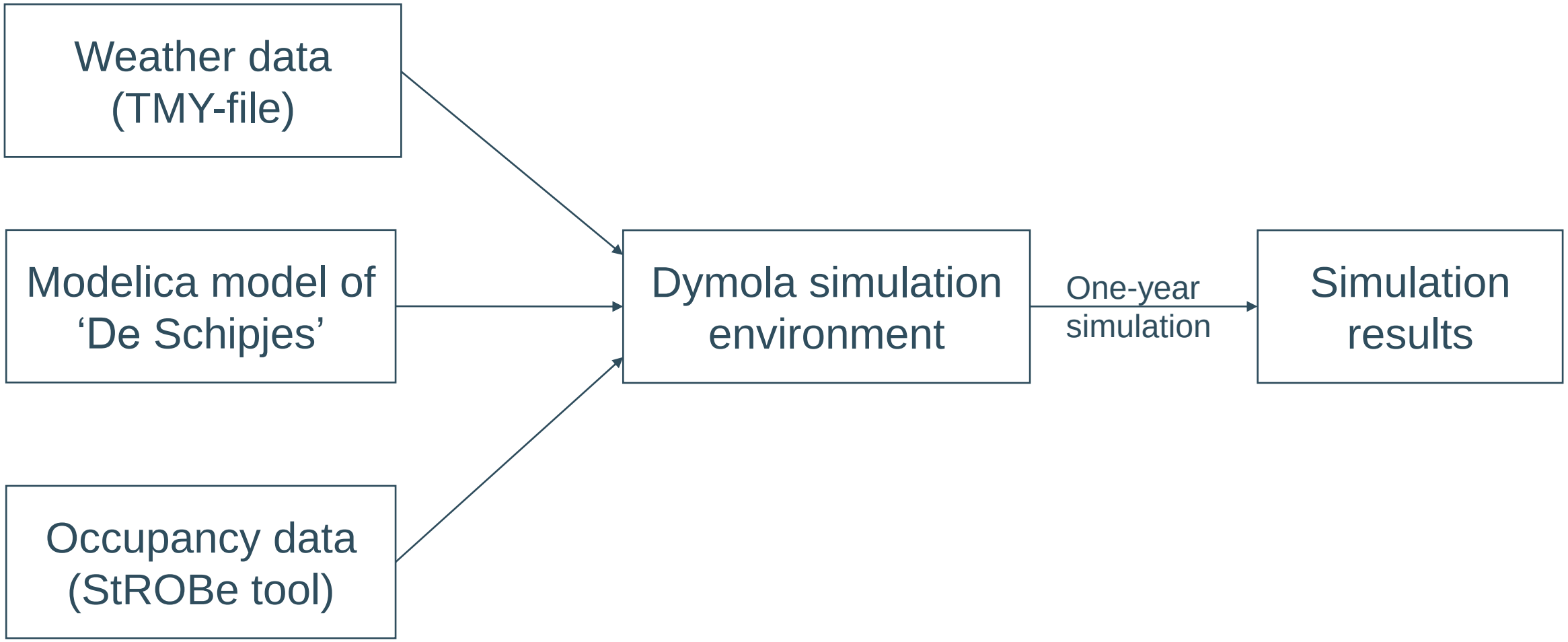


Simulations – control strategy

- Reference RBC
  - On/off control GSHP (50°C)
  - Heating curve building's heating system
  - Night setback
  - DHW > SH
  - On/off control BHP (45/60°C)
- Alternative RBCs[1,2,3]
  1. Preheating DHW
  2. Simultaneous SH (radiators) and DHW production
  3. FH active during night
  4. Heating curve DH network

[1] Feyaerts, S. (2019). Impact van de regeling op de performantie van een klein thermisch net voor godshuizen, De Schipjes, te Brugge. Master's thesis, KU Leuven, Belgium, 2019.
[2] Boydens, W., Feyaerts, S., Vandermeulen, A., Helsen, L., Jansen, J. (2021). Control strategy assessment of a small GSHP sourced DH system with end user DHW booster heat pumps. 12th IEA Heat Pump Conference. Jeju (Korea), 26-29 April 2021.
[3] Jansen, J., Maertens, F., Boydens, W., Helsen, L. (2021). Living lab 'De Schipjes': a zero-fossil-fuel energy concept in the historic city center of Bruges. 17th Building Simulation Conference. Bruges (Belgium), 1-3 September 2021.

Simulations – methodology



Simulations – control strategy

$$\sum_{buildings} \int_{t_{start}}^{t_{end}} \max\left(0, (T_{set}(t) - 1) - T_{zone}(t)\right) dt$$

	RBC	Primary energy use [GJ]	RES share [%]	COP GSHP [-]	COP BHP [-]	Thermal discomfort [Kh]
1	Reference	321.7	63.2	2.68	3.59	2687
2	Preheating DHW	321.9	63.1	2.67	3.54	2668
3	Simultaneous SH	323.7	63.3	2.69	3.62	**2176**
4	Continuous FH	325.6	64.5	2.67	3.59	**1391**
5	Heating curve	**299.6**	**73.7**	**3.83**	3.60	3257
6	Combination (3,4,5)	**304.4**	**73.7**	**3.83**	3.59	**1438**

Current/future research

- Implementing a model predictive controller (**MPC**) for ‘De Schipjes’
  - TACO (Toolchain for automated control and optimisation)[4]
  - Minimise total electricity use while guaranteeing thermal/DHW comfort
  - Results for a three-day simulation (January 28-31)

	Thermal discomfort [Kh]	DHW discomfort [Kh]	Electricity use [MJ]	COP GSHP [-]	COP BHP [-]
RBC	190	0	2096	3.34	3.63
MPC	15	0	1864	3.91	3.81
Difference	-92%	/	-11%	+17%	+5%

[4] Jorissen, F., Boydens, W., Helsen, L. (2019). TACO, an automated toolchain for model predictive control of building systems: implementation and verification. Journal of Building Performance Simulation, 12(2), 180-192.

Questions?

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