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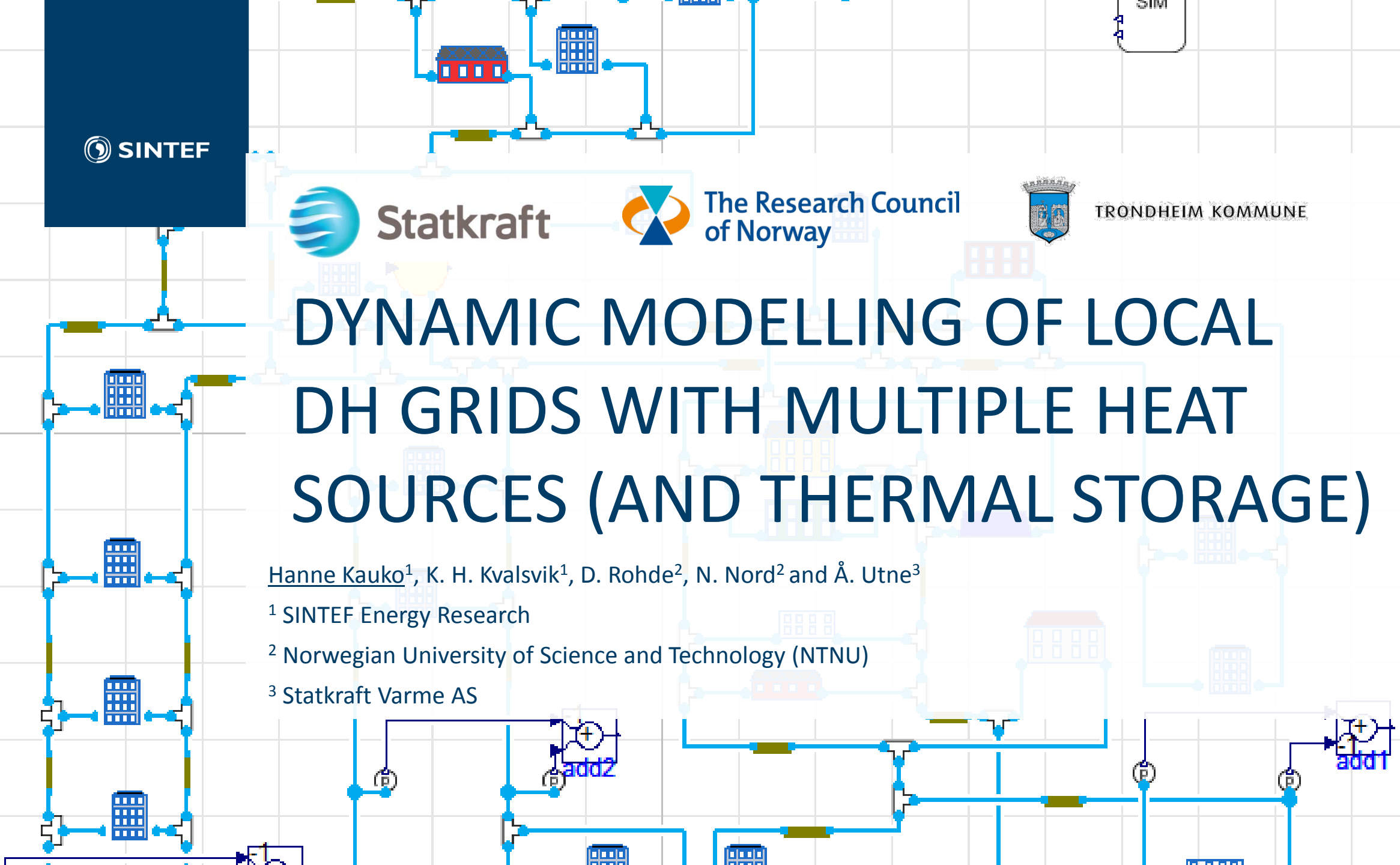
DYNAMIC MODELLING OF LOCAL DH GRIDS WITH MULTIPLE HEAT SOURCES (AND THERMAL STORAGE)

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Background

- Shift to 4th generation DH has to start from new building areas
 - Desire to study different heat supply scenarios for new building areas
- Energy system model, with the main interest to study
 - How to satisfy the heat load for a certain area through the year
 - How to integrate multiple heat suppliers (and thermal storage)
 - Utilization of urban waste heat
- Yet another tool...?

Dynamic Energy System Modeling

- "Dynamic" instead of steady-state: new opportunities and added complexity
 - Necessary realism in systems with energy storage
 - Tanks, thermal mass in constructions and pipes
 - Requires a control strategy and a control system
- Physical models in Modelica/Dymola
 - Object-oriented, easy reuse of components
 - Flexible, full control of code

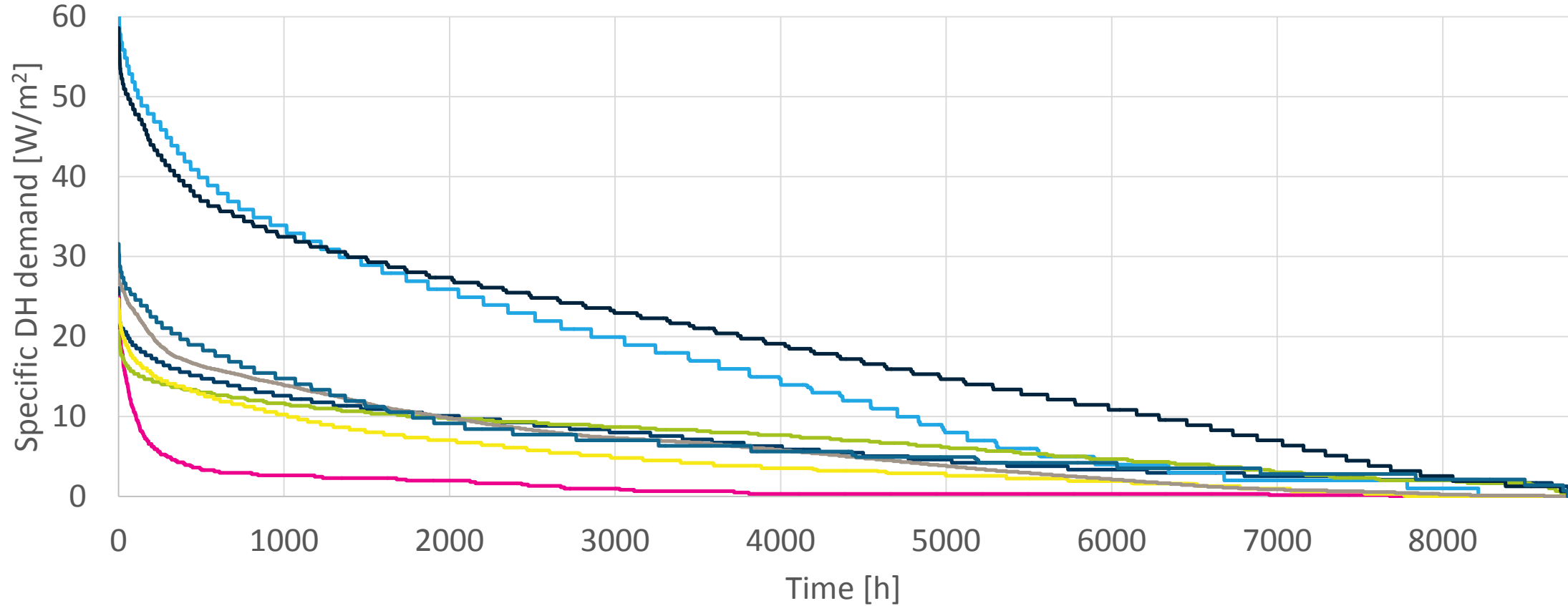
The Modelled Building Area



Building type	Number	Total area [m ²]	Share
Apartment block	18	140 898	75 %
Nursery	3	2 400	2 %
School	1	6 000	3 %
Nursing home	1	12 600	7 %
Culture building	1	4 000	2 %
Main building	1	5 850	3 %
Psychiatric hospital	1	3 700	2 %
Sports hall	1	10 000	5 %
Total	28	185 748	100 %

The Modelled Building Area

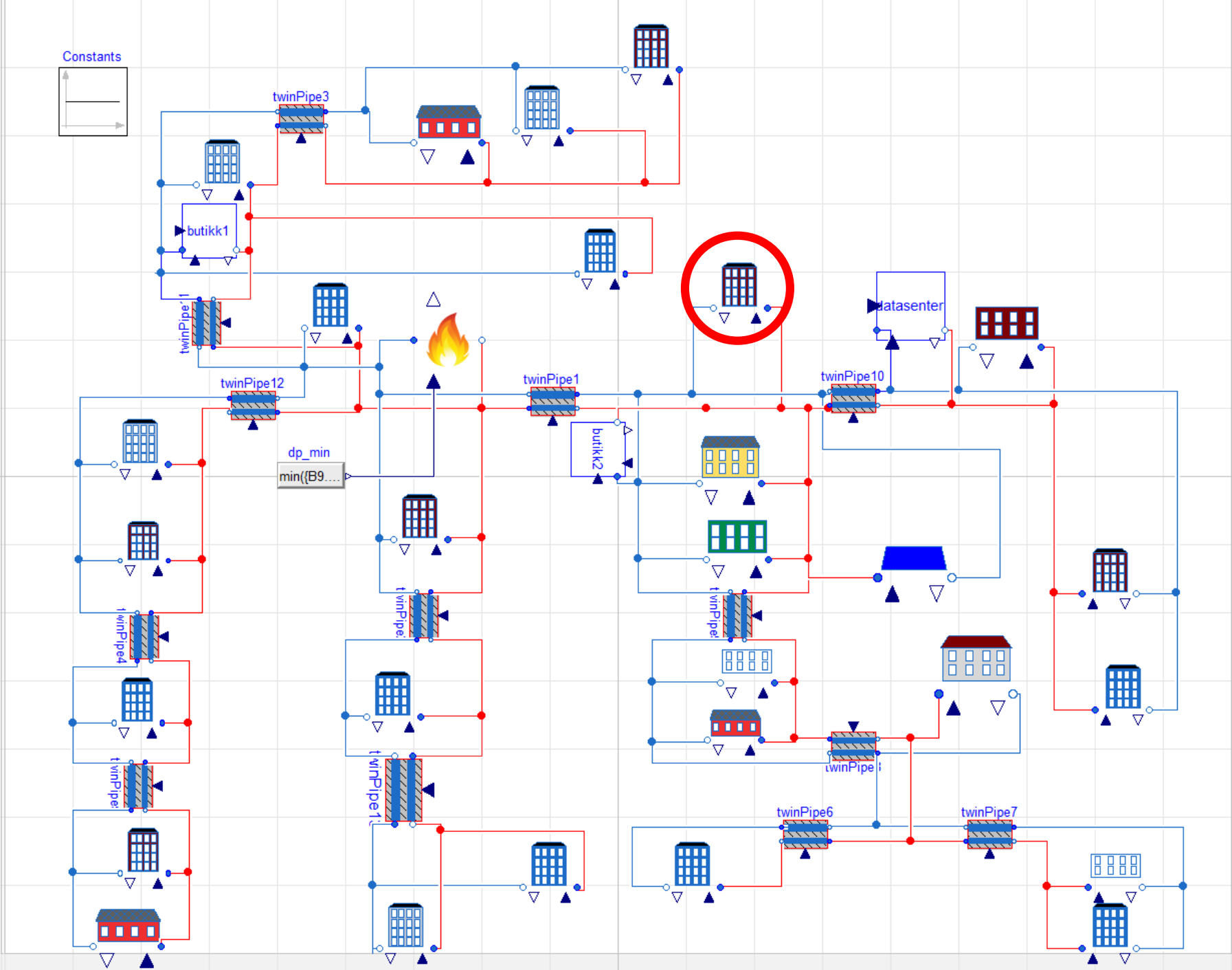
DH demand



- Apartment building
- Culture building
- Main building
- Nursery
- Psychiatric hospital
- School
- Nursing home
- Sportshall

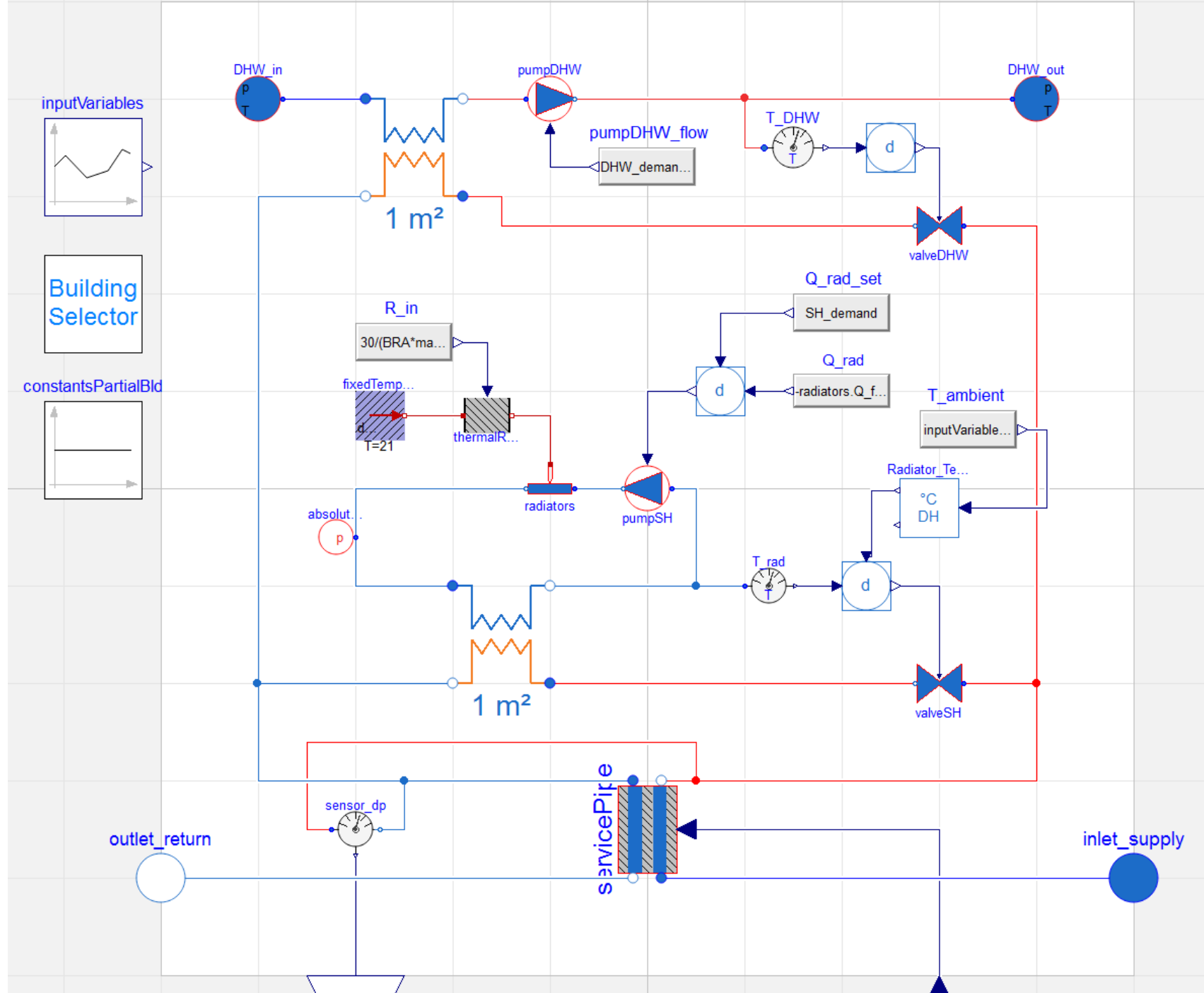
The Model

The Network



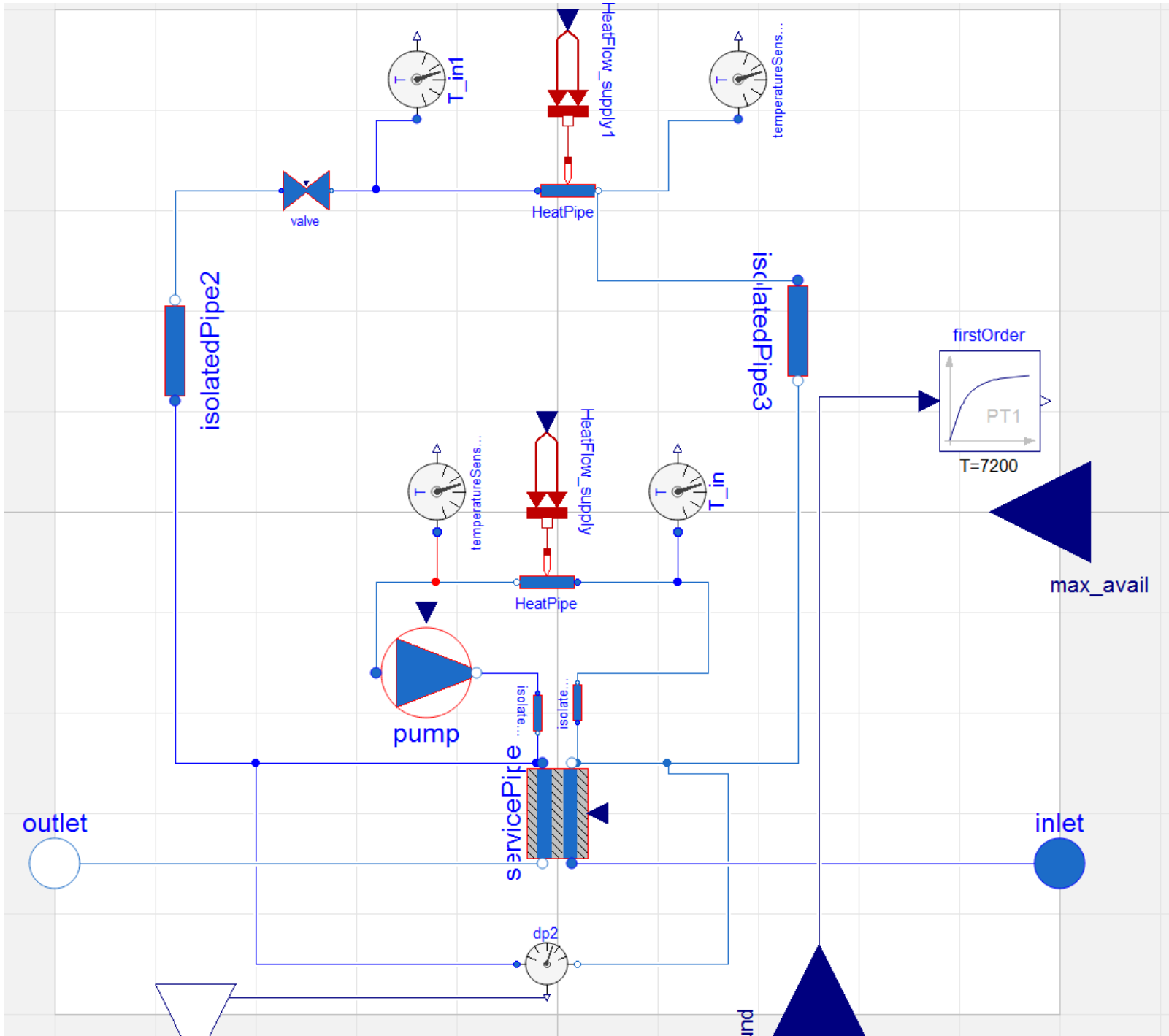
The Model

Customer substation



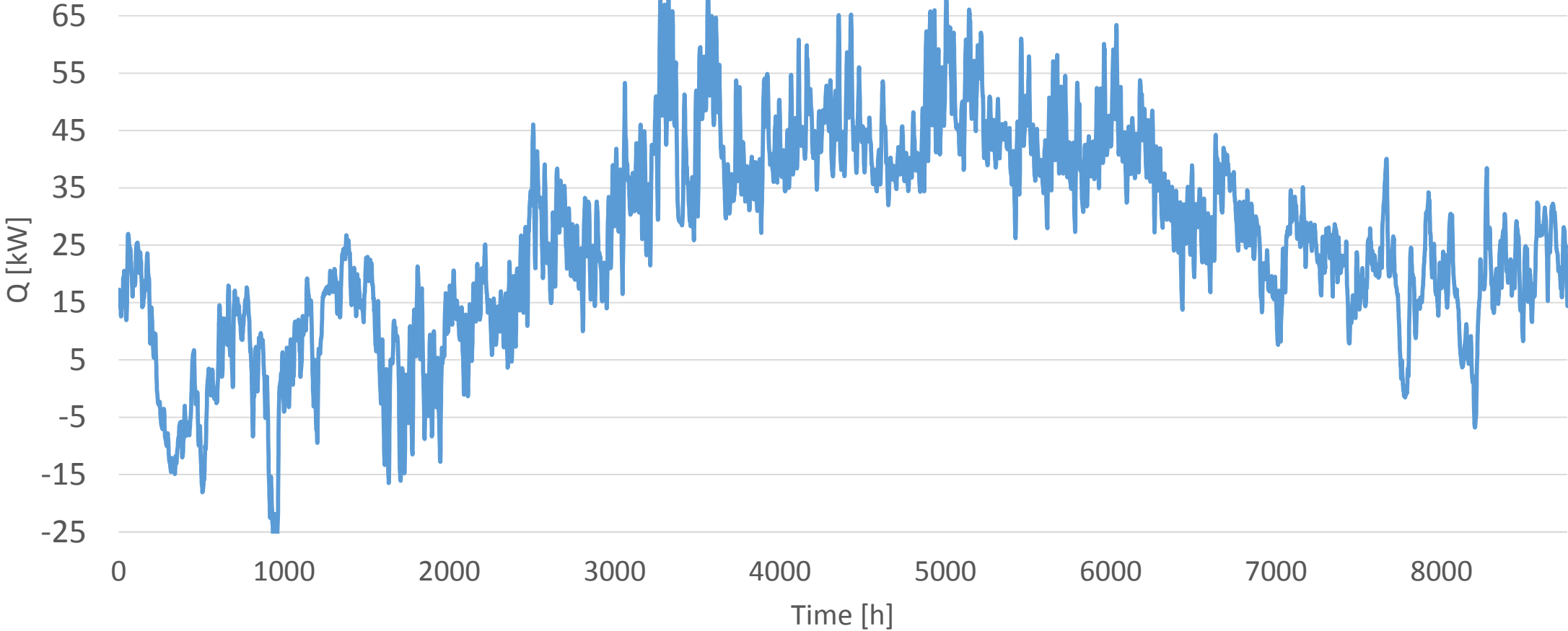
The Model

Surplus heat suppliers



The Model

Surplus heat suppliers



Simulations

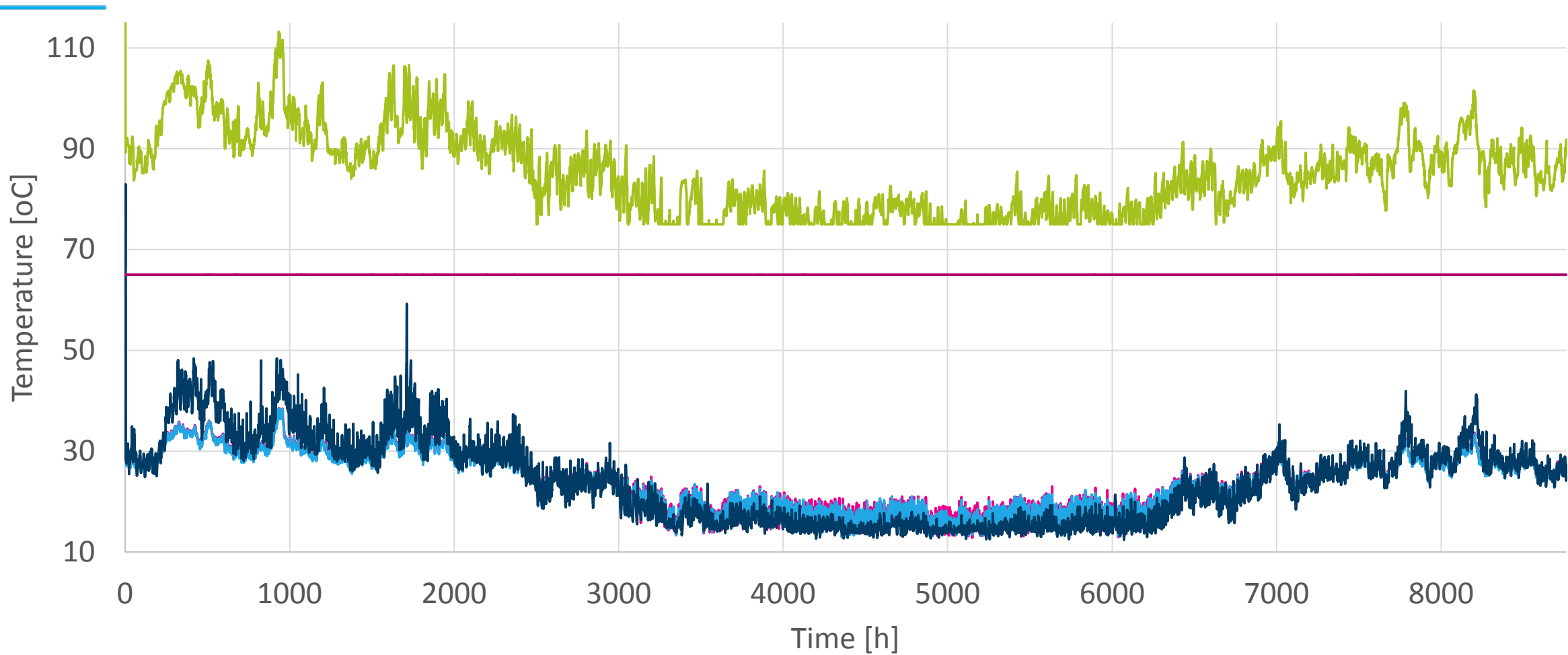
Name of case/scenario	Supply temperature [°C]	Return temperature [°C]	Special
HT	95-70	47.5-35.0	Supply temperature compensated with the outdoor temperature
LT	65	32.5	Constant supply temperature
LT+	65	32.5	Surplus heat supply <ul style="list-style-type: none">- 2 supermarkets with a max heat output of ca 65 kW- 1 data centre with a max heat output of 210 kW

Results

	Delivered heat		Heat loss		Total pump work		$Q_{\text{loss}}/Q_{\text{tot}}$
	[MWh]	% of HT	[MWh]	% of HT	[MWh]	% of HT	
HT	13 351	100 %	609	100 %	13	100 %	4.6 %
LT	13 279	99 %	489	80 %	21	161 %	3.7 %
LT+	11 070	83 %	477	78 %	19	150 %	4.3 %

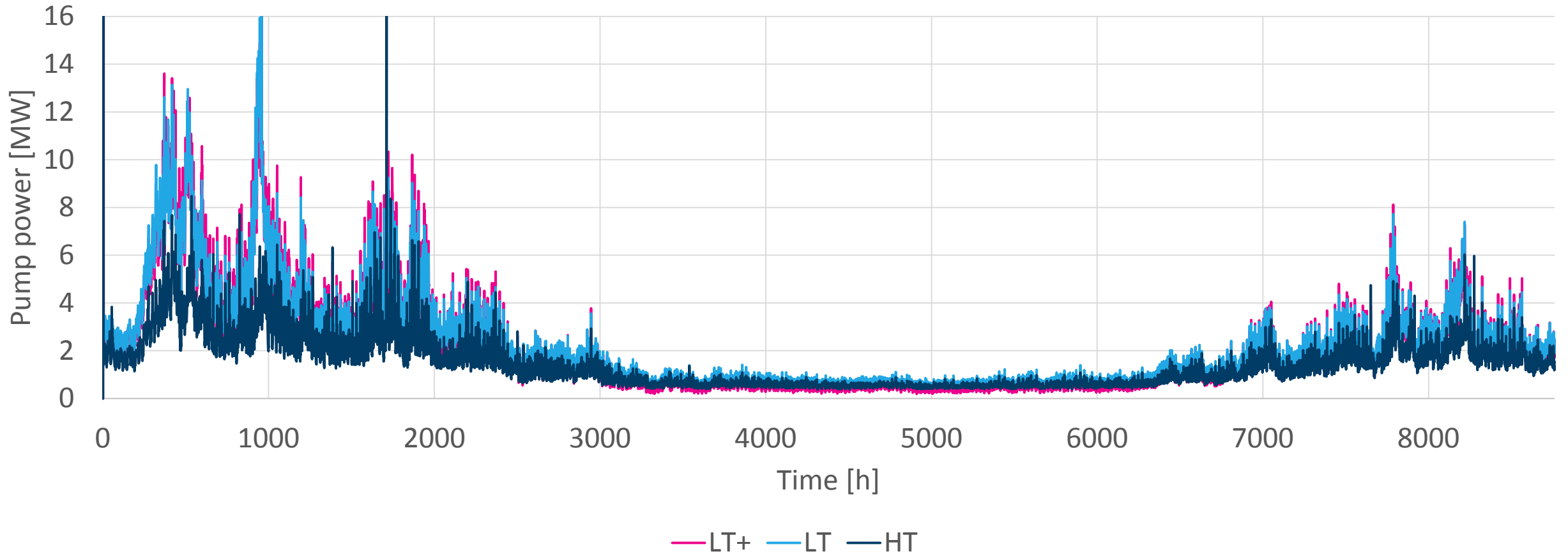
Results

Supply and return temperatures



Results

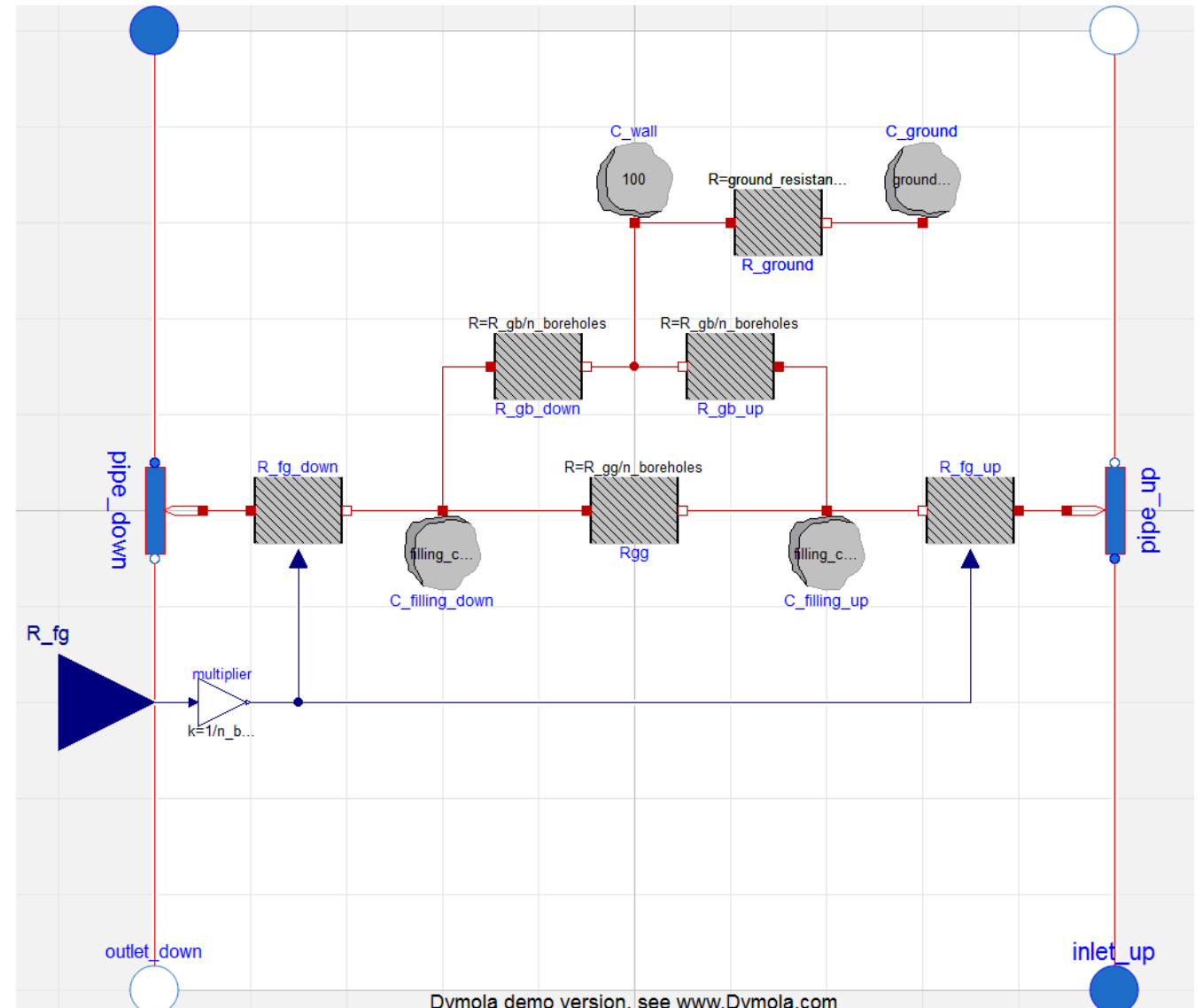
Pumping power



Additional heat sources + thermal storage = Self-supplied network?

Borehole thermal energy storage
model by Daniel Rohde (PhD
candidate, NTNU)

Based on
Bauer, D. et al. Transient 3D analysis of borehole heat
exchanger modeling. *Geothermics* 40.4 (2011): 250-260.



Additional heat sources + thermal storage = Self-supplied network?

- Requires huge numbers of solar collectors and storage capacity (energy wells)
 - Approx. 50 000 m² of solar collectors → huge investment!
- Source-storage interaction difficult to model
 - Control dynamics and decision-making
 - Working on it..

Summary & Conclusions

- Dynamic modelling gives the possibility to realistically study the impact of
 - Changing supply temperature
 - Multiple heat sources

...in the network, from a thermodynamic point of view

- It may not be the best approach for
 - Cost-optimization studies
 - Preliminary studies, coarse dimensioning

Thank you for your attention.



The Research Council
of Norway

Questions?

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Statkraft



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Teknologi for et bedre samfunn