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The Research Council of Norway

TRONDHEIM KOMMUNE

MODELLING LOCAL LOW-TEMPERATURE DH GRIDS - A CASE STUDY FOR NORWAY

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September 2016

Backround

- Desire to shift to lower supply temperatures
- Norway: distribution temperatures limited to 65 °C
- **Goal**: Study the effect of lowered distribution temperatures to heat losses and pumping power

  → Case study for a new green district to be built in Trondheim

Building stock at Brøset

Building type	Number	Total area [m²]	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 %

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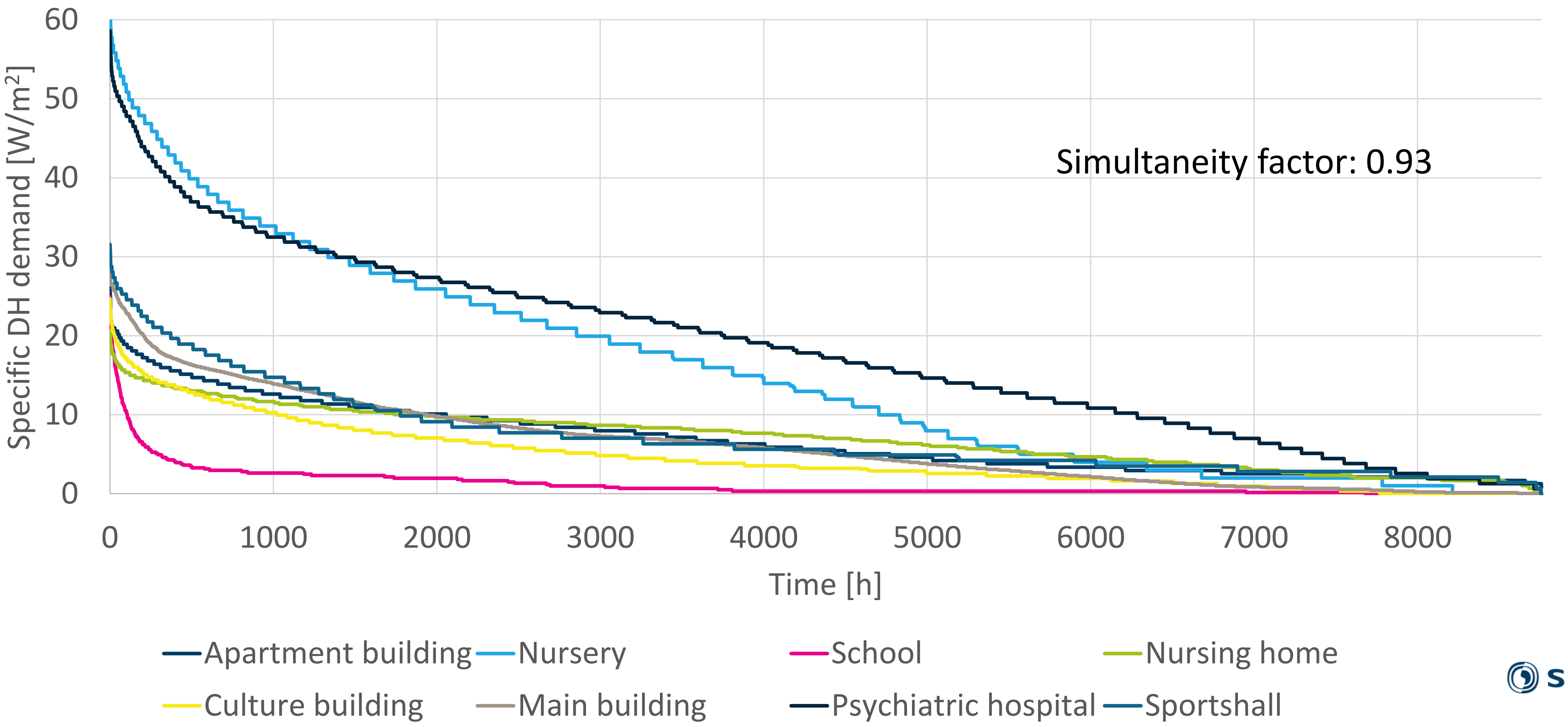
Building stock

DH demand



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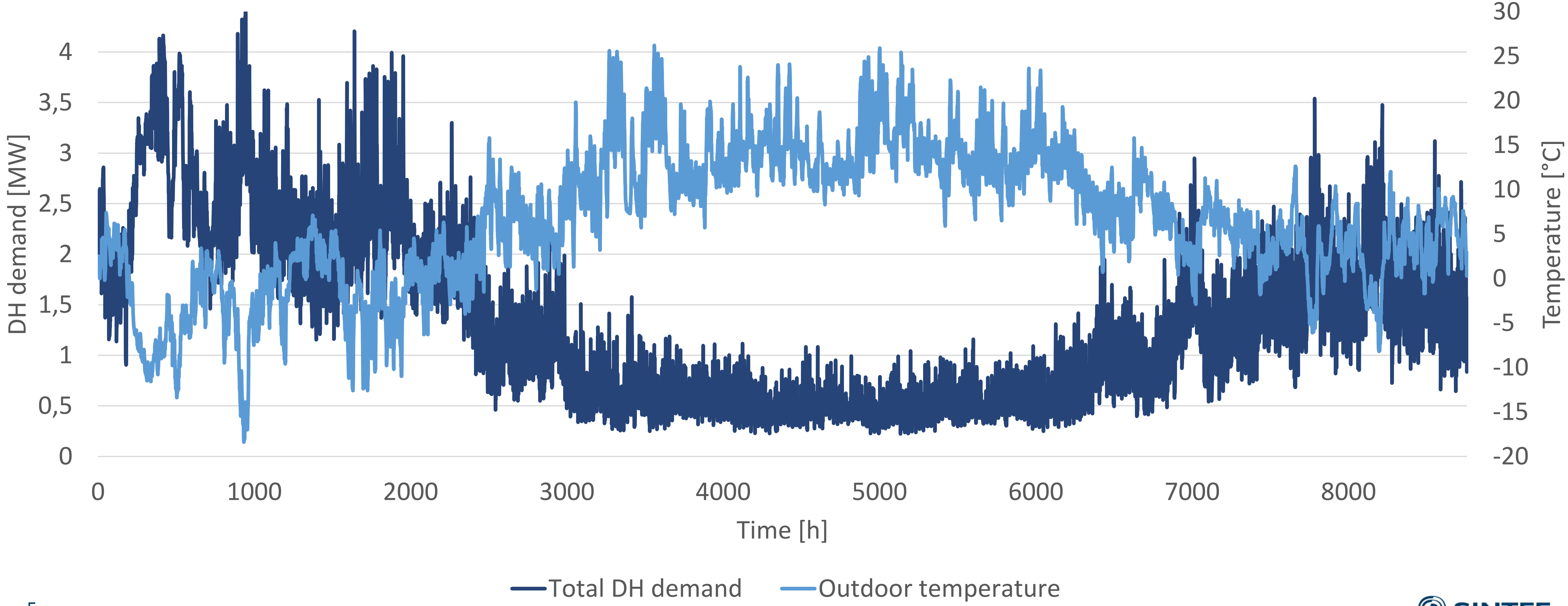
Building stock

Total DH demand and outdoor temperature for 2013



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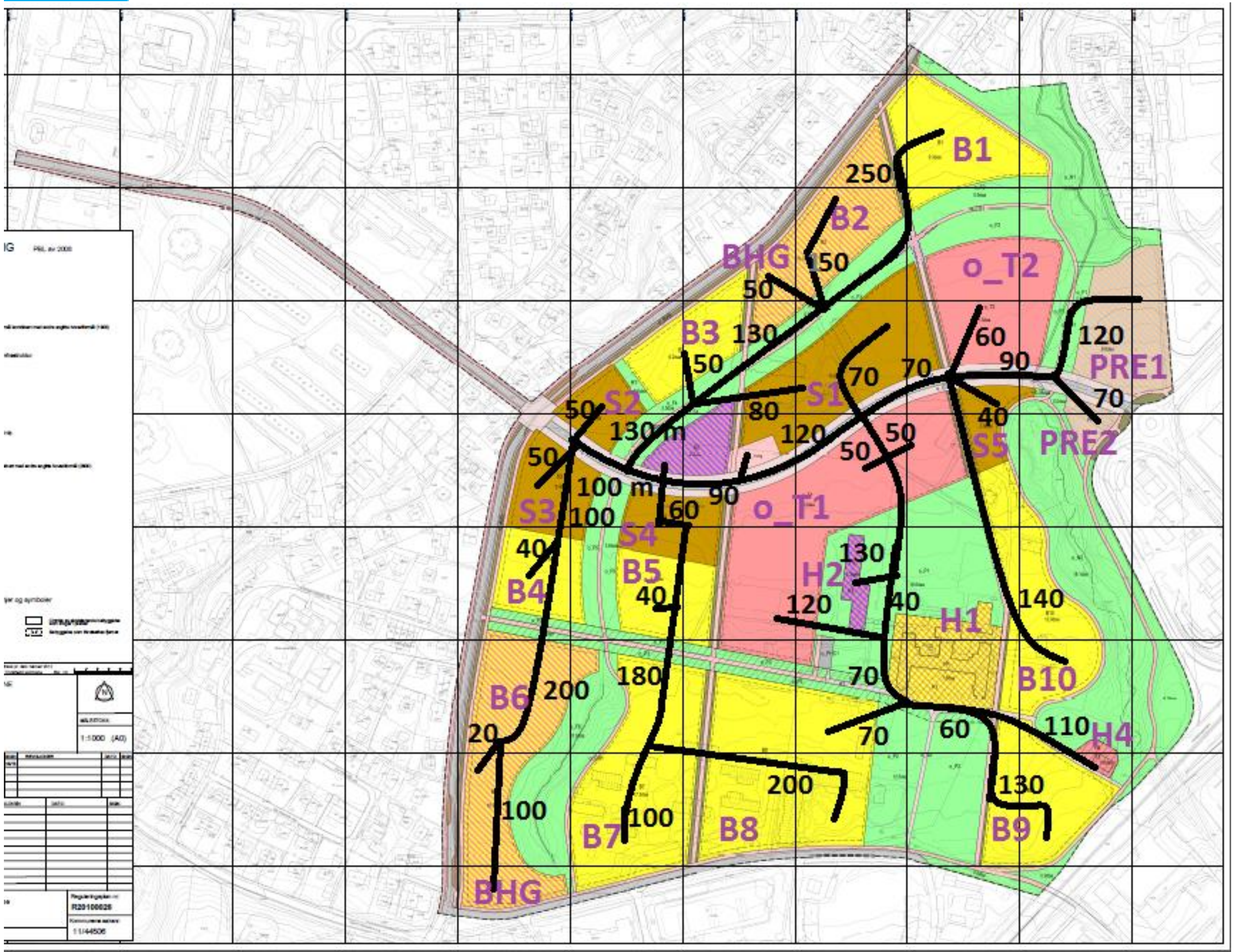
The network



- Areas with similar building types were represented as single large buildings
- Piping distances approximated using the building plan

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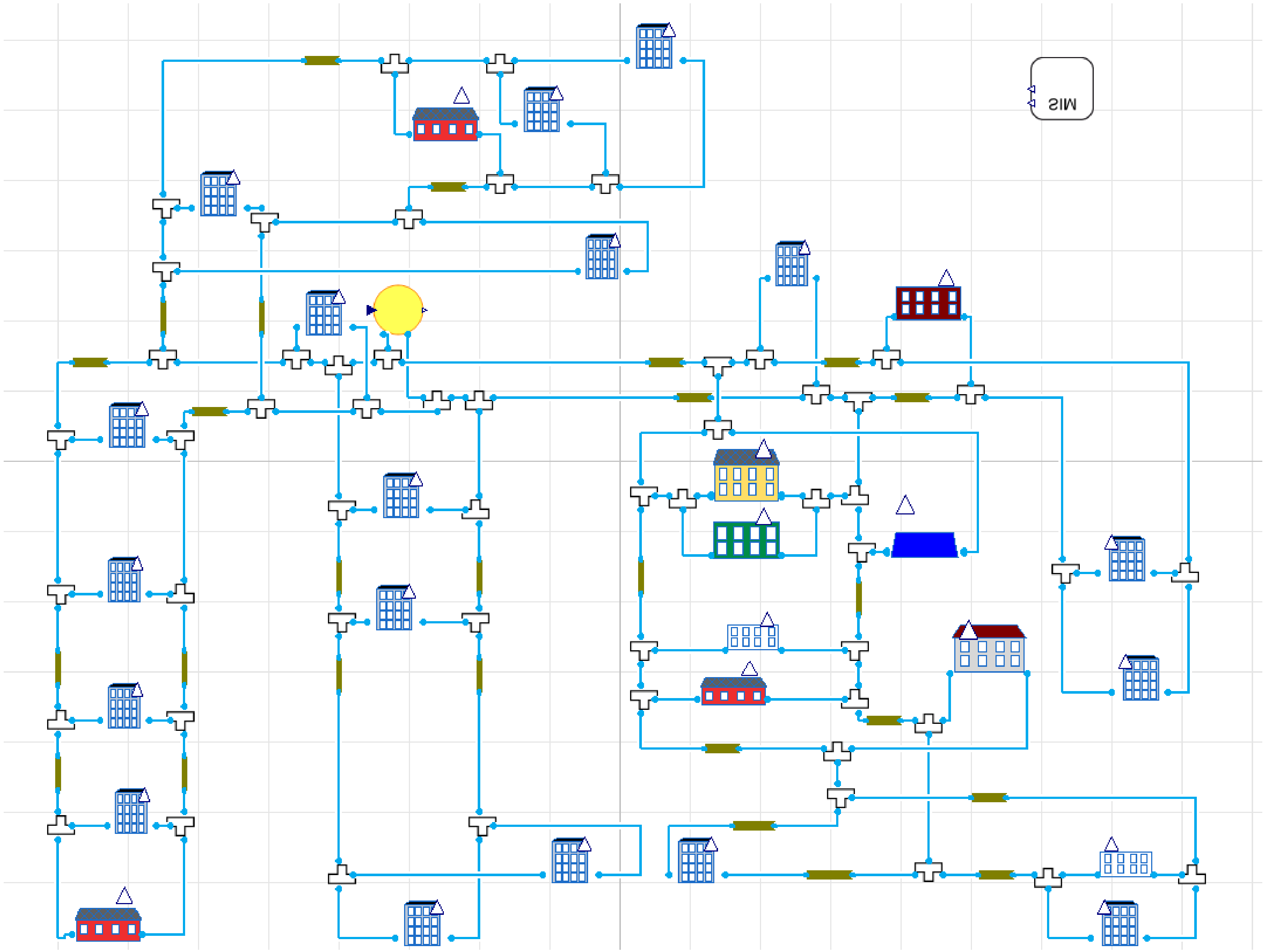
The network

- Dymola - dynamic modelling laboratory
- Object oriented language Modelica



The network

Selecting the pipe diameter for each segment

Simulate one year assuming uniform pipe diameters

→

Find maximum mass flow in each pipe over a year

→

Find the respective pipe diameter based on

$$D = 0.0379 \cdot \dot{m}_{max}^{0.37}$$

→

Round up to the nearest real diameter

The network

Pipe diameters and maximum mass flow

1. Choose arbitrary mass flow in relevant range
2. Assume maximum pressure drop, $\Delta p / L = 150$ Pa/m
3. Estimate diameter such that the following expressions are valid

$$\Delta p = f \cdot \frac{L}{D}\frac{\rho v^2}{2} = f \cdot \frac{8L\dot{m}^2}{\pi^2 D^5 \rho} \qquad \frac{1}{\sqrt{f}} = -2.0 \cdot log_{10}\left(\frac{2.51}{\sqrt{f}\,Re}\right)$$

f: friction factor
ρ: water density
v: water velocity
Re: Reynold's number

4. Find an expression for diameter as a function of maximum mass flow

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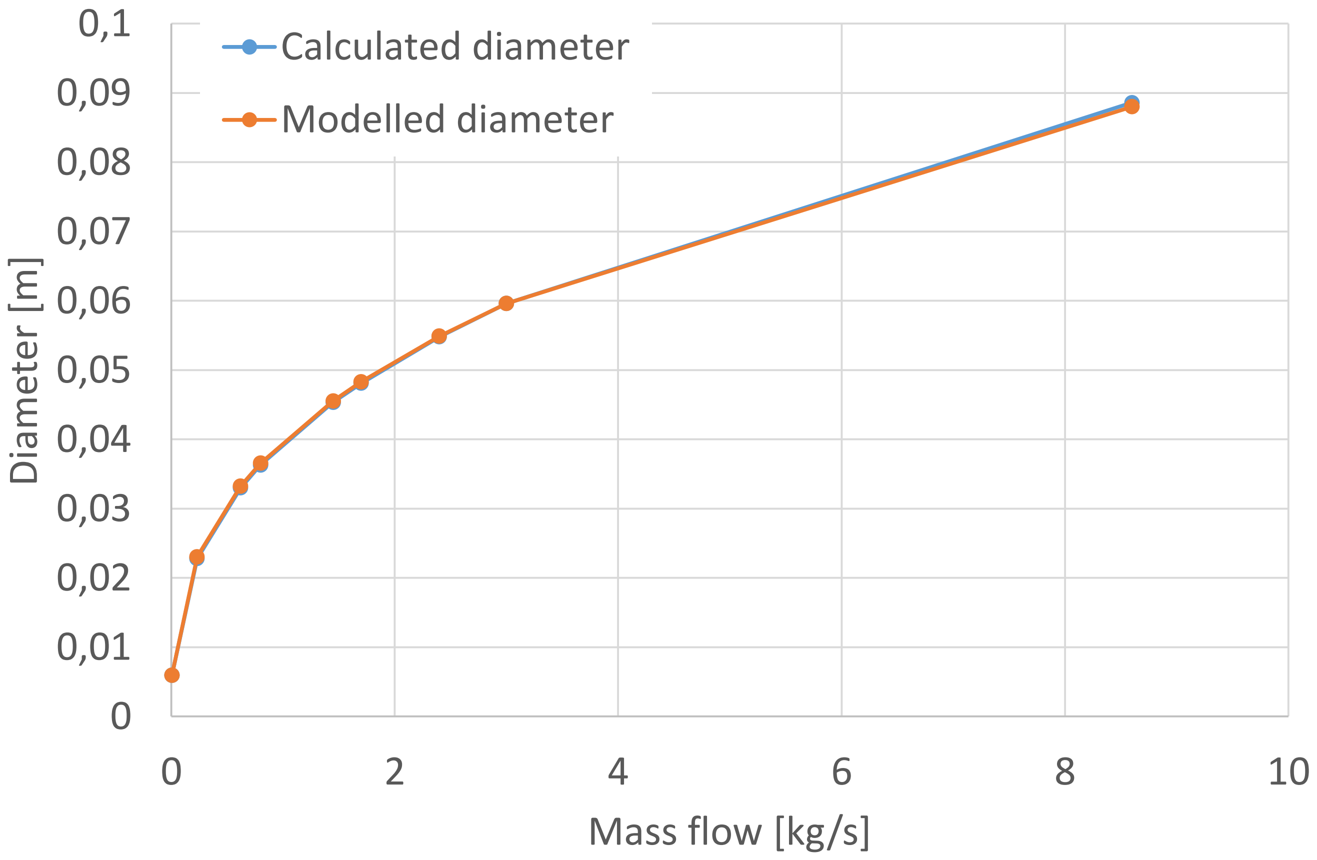
The network

Pipe diameters and maximum mass flow



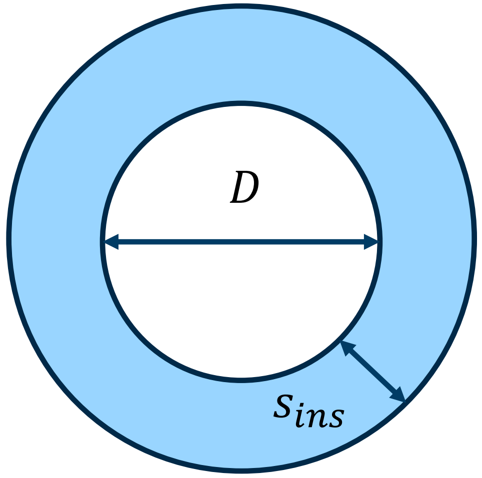
$$D = 0.0379 \cdot \dot{m}_{max}^{0.37}$$

The network

Heat loss

- Conduction heat transfer was found to be the dominating loss mechanism
- Heat loss calculated as

$$\dot{Q}_{loss} = \frac{2L\pi \lambda_{ins}\left(T_{water} - T_{ground}\right)}{ln\left(\frac{2s_{ins} + D}{D}\right)}$$



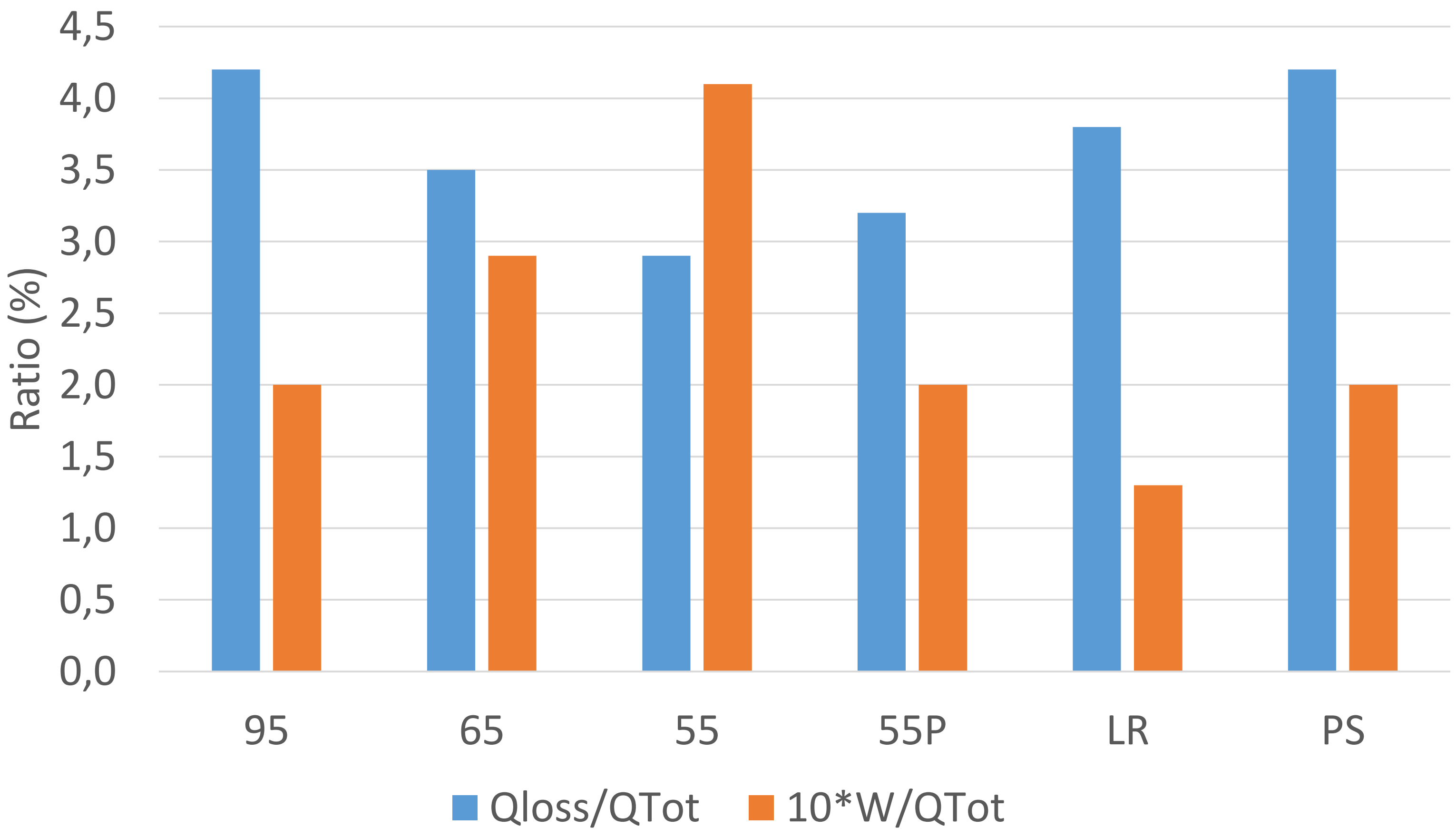
  - λ_{ins}= 0.022 W/Km
  - T_{ground}=5°C (assumed constant)
  - Insulation thickness s_{ins} chosen based on the pipe diameter.

Simulations

Name of case/scenario	Supply temperature [°C]	Return temperature [°C]	Special
95	95-70	47.5-35.0	Supply temperature compensated with the outdoor temperature
65	65	32.5	Constant supply temperature
55	55	27.5	Constant supply temperature
55P	55	27.5	Pipe diameters 50 % larger
Low return - LR	95-70	40.5-28.0	Low return temperature (by 7 °C)
Peak shaving - PS	95-70	47.5-35.0	Peak Shaving (maximum demand reduced by 20 %)

Results

Heat loss and pump work



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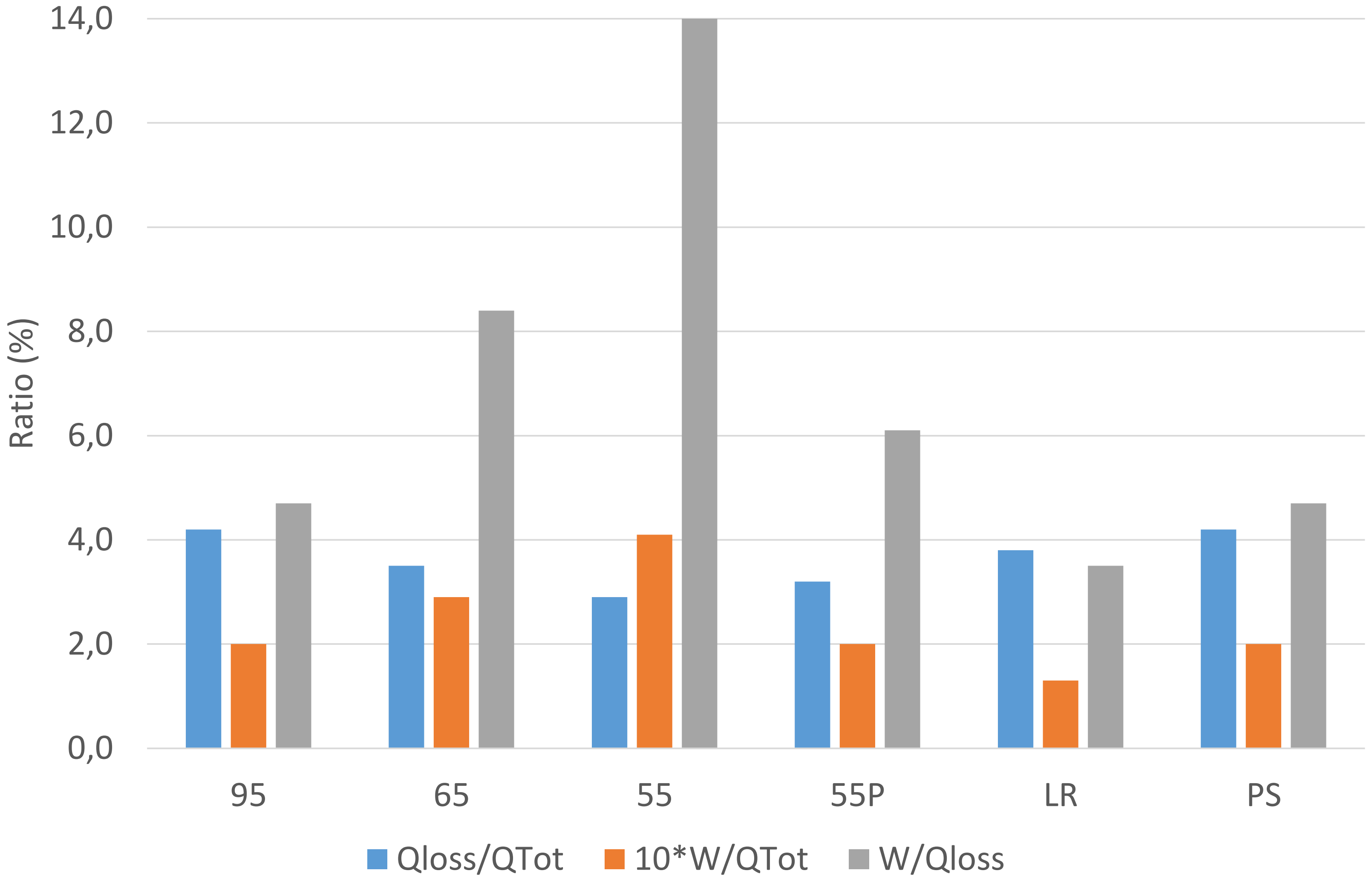
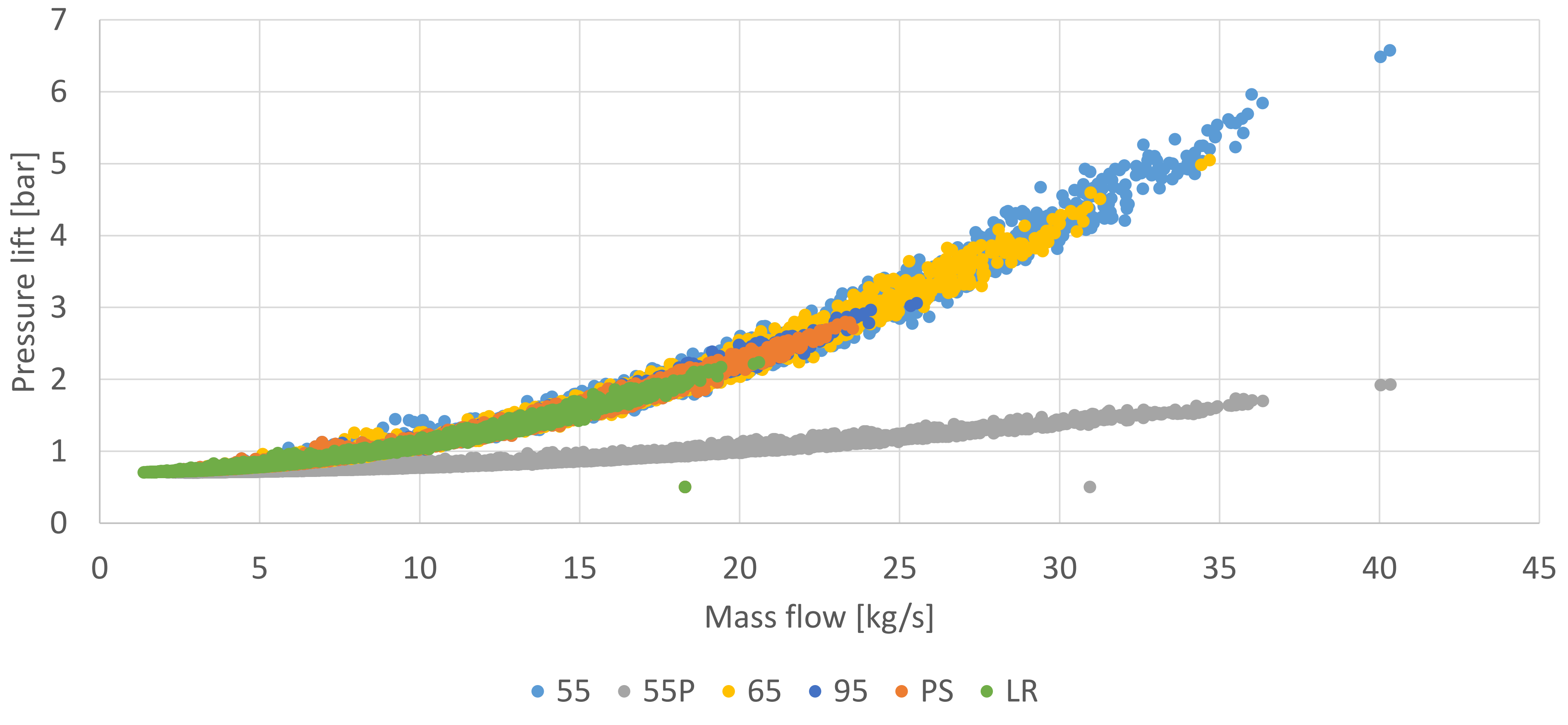
Results

Heat loss and pump work



Results

Pressure lift as a function of mass flow



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Summary & Conclusions

- Local DH grid has been modelled for a green district in Trondheim Norway
- Heat losses and pump work analyzed for different supply temperature levels
- Results
  - 30 % lower heat loss with and 100 % higher pump work for 55 °C supply temperature case compared to the base case
  - Pump work only ~1/10 of the heat loss
  - Lowest pump work when applying low return temperature
- Next steps
  - Refining the model
  - Including different heat sources and thermal storage
  - Including cost analysis

Thank you for your attention.

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Teknologi for et bedre samfunn

Results

Heat loss and pump work (W)

Variable\Case	95	65	55	55P	LR	PS
Q_{Tot}	100,0	99,3	98,6	99,0	99,7	100,0
Q_{loss}	100,0	83,6	69,2	76,8	90,8	100,0
W	100,0	150,2	208,6	100,0	67,3	99,9

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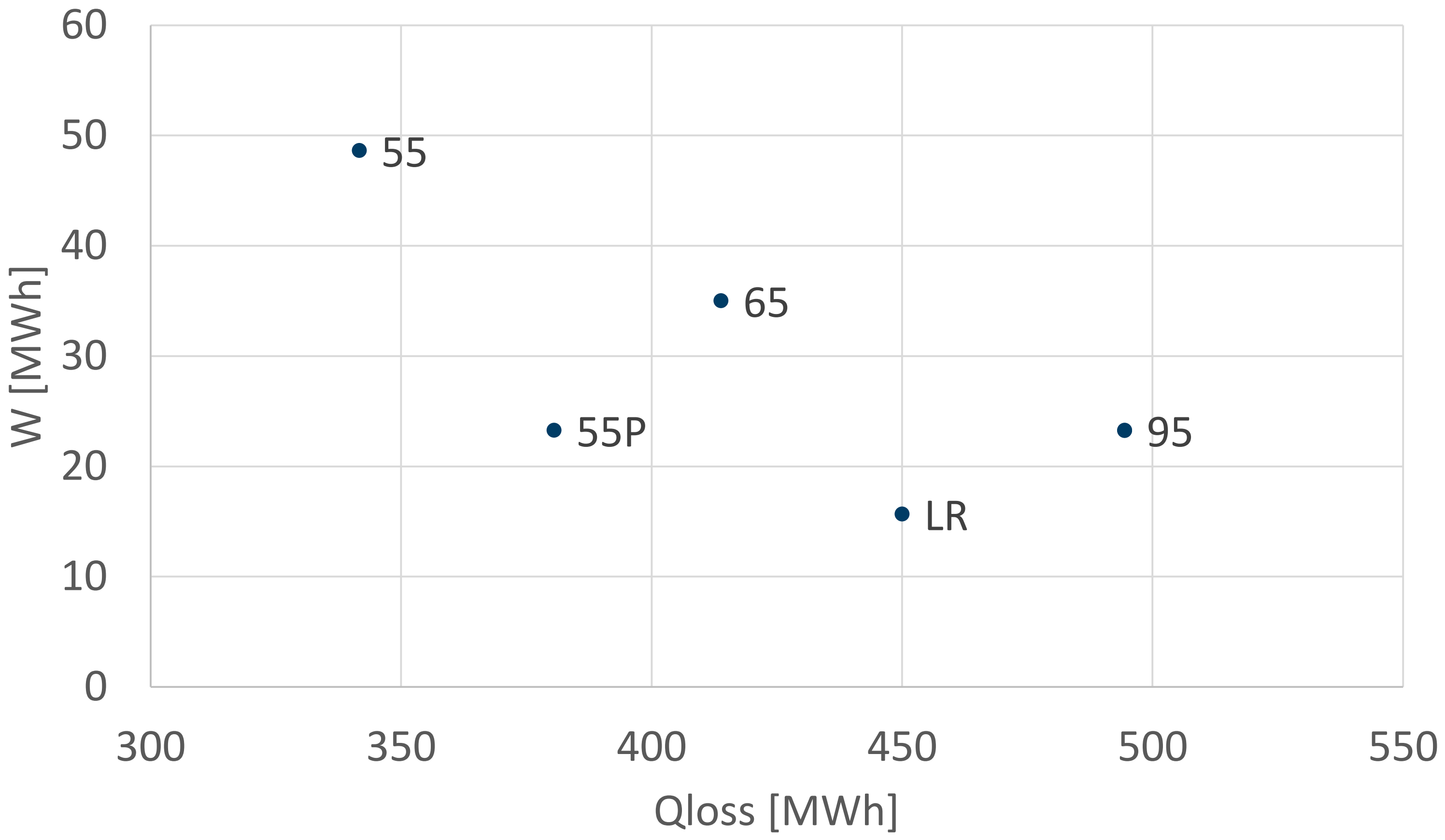
Results

Heat loss and pump work



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