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Thermo-hydraulic implications of different design guidelines for 4th Generation District Heating Networks

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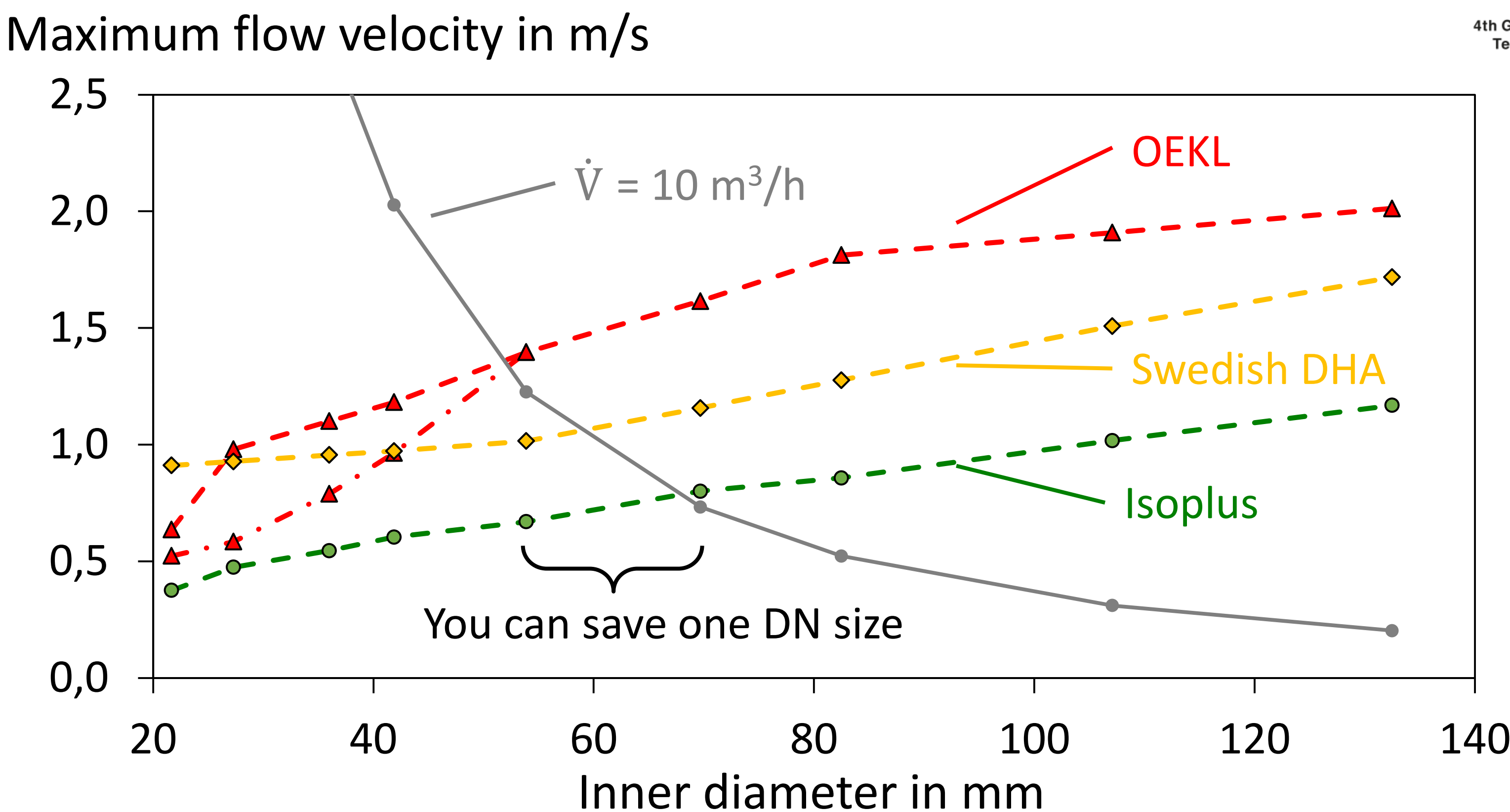
4DH
4th Generation District Heating
Technologies and Systems

Motivation:

Differing design guidelines for pipe diameters



→ Which one to use?

Sources:
Swedish District Heating Association, Recommendations for Installation of District Heating and Cooling Pipes (in Swedish). Stockholm 2009
ÖKL-Arbeitskreis Landwirtschaftsbau. Planung von Biomasseheizwerken und Nahwärmenetzen. Wien: Österreichisches Kuratorium für Landtechnik und Landentwicklung; 2016; Available from: http://oekl.at/publikationen/merkblaetter/mb67/ [Nov 02, 2018].
ISOPLUS. Planungshandbuch: Kapitel Starre Verbundsysteme. Available from: isoplus.de [Nov 02, 2018].

Motivation:
What about thermo-hydraulic performance?

Previous result: Economic comparison[1]

→ Design for higher pressure drop reduces total heat distribution cost

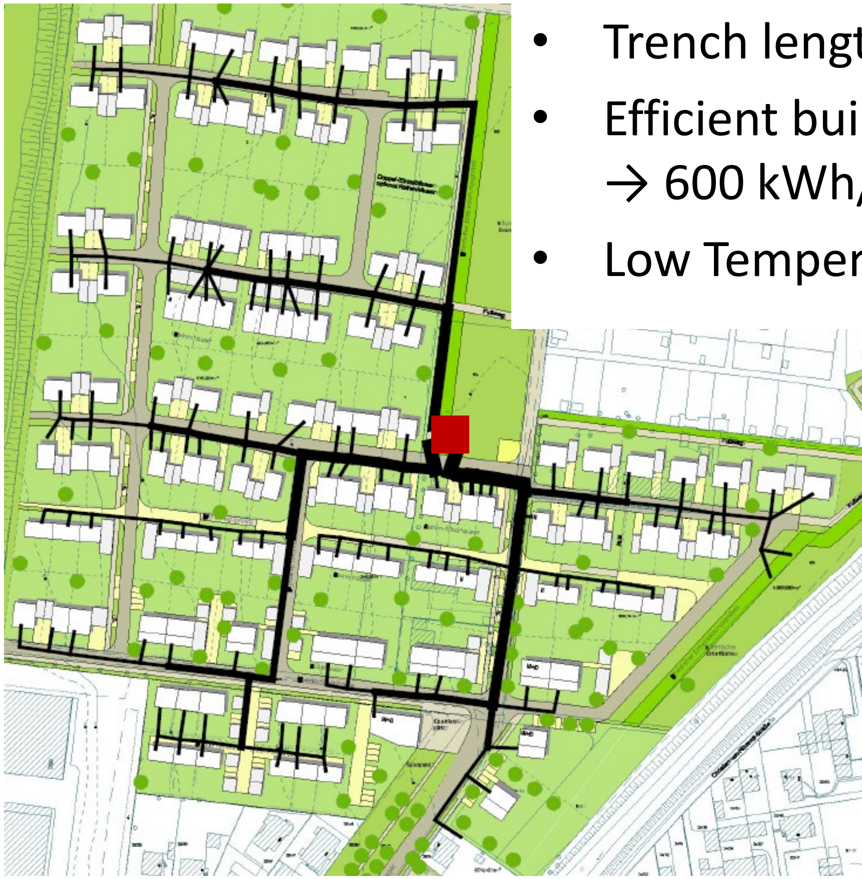
Now: Detailed annual simulations of the network

Δp? W_{pump}? Q_{loss}? $\dot{m}_{\mathrm{bypass}}$? $\bar{T}_{\mathrm{return}}$?

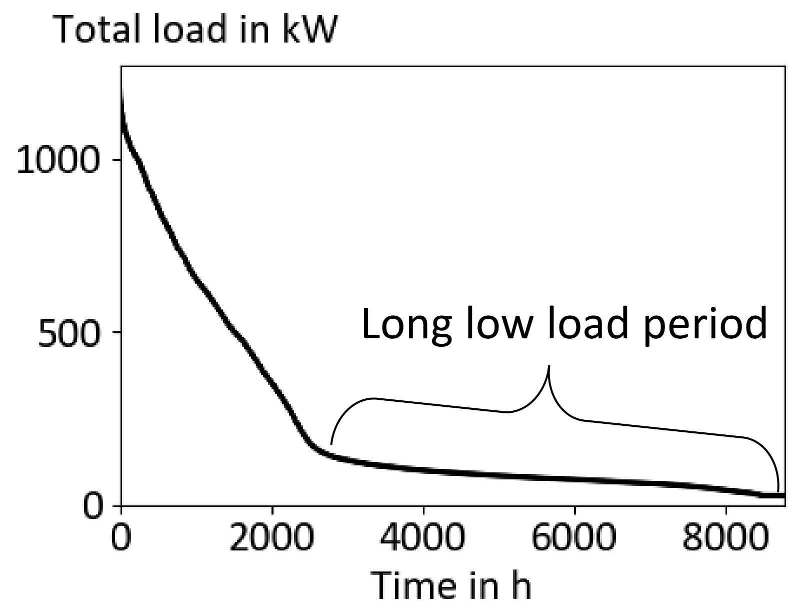
→ Any drawbacks of designing for higher pressure drops?

[1] I. Best et al.: *Impact of Different Design Guidelines on the Total Distribution Costs of 4th Generation District Heating Networks*;16th International Symposium on District Heating and Cooling, DHC2018; Energy Procedia 2018, Volume 149

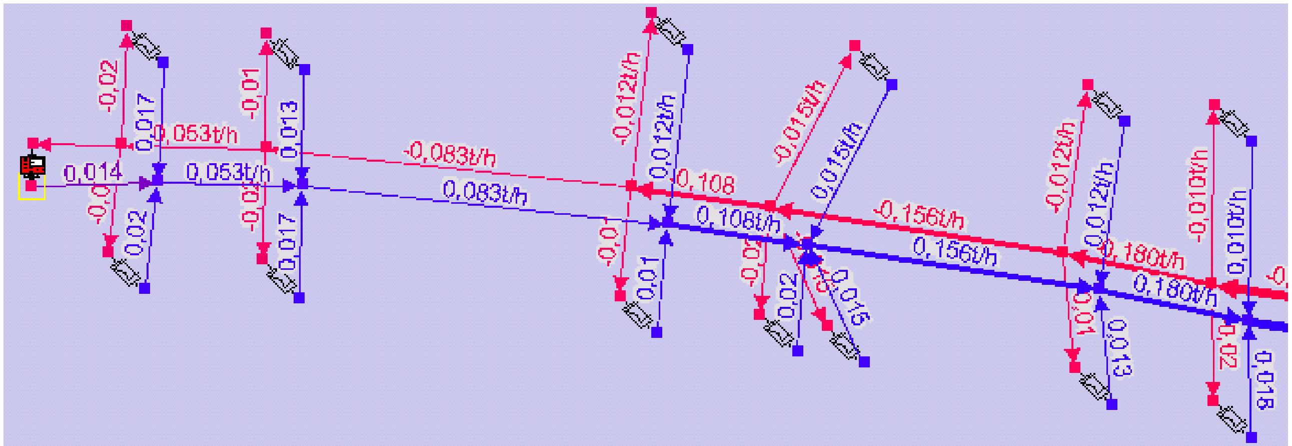
Case Study:
A small LTDH-network



- Trench length: 3 km
- Efficient buildings: Heat demand 1800 MWh/a → 600 kWh/(m·a), 27 % DHW
- Low Temperature District Heating: 70 °C/40 °C



Simulation Model

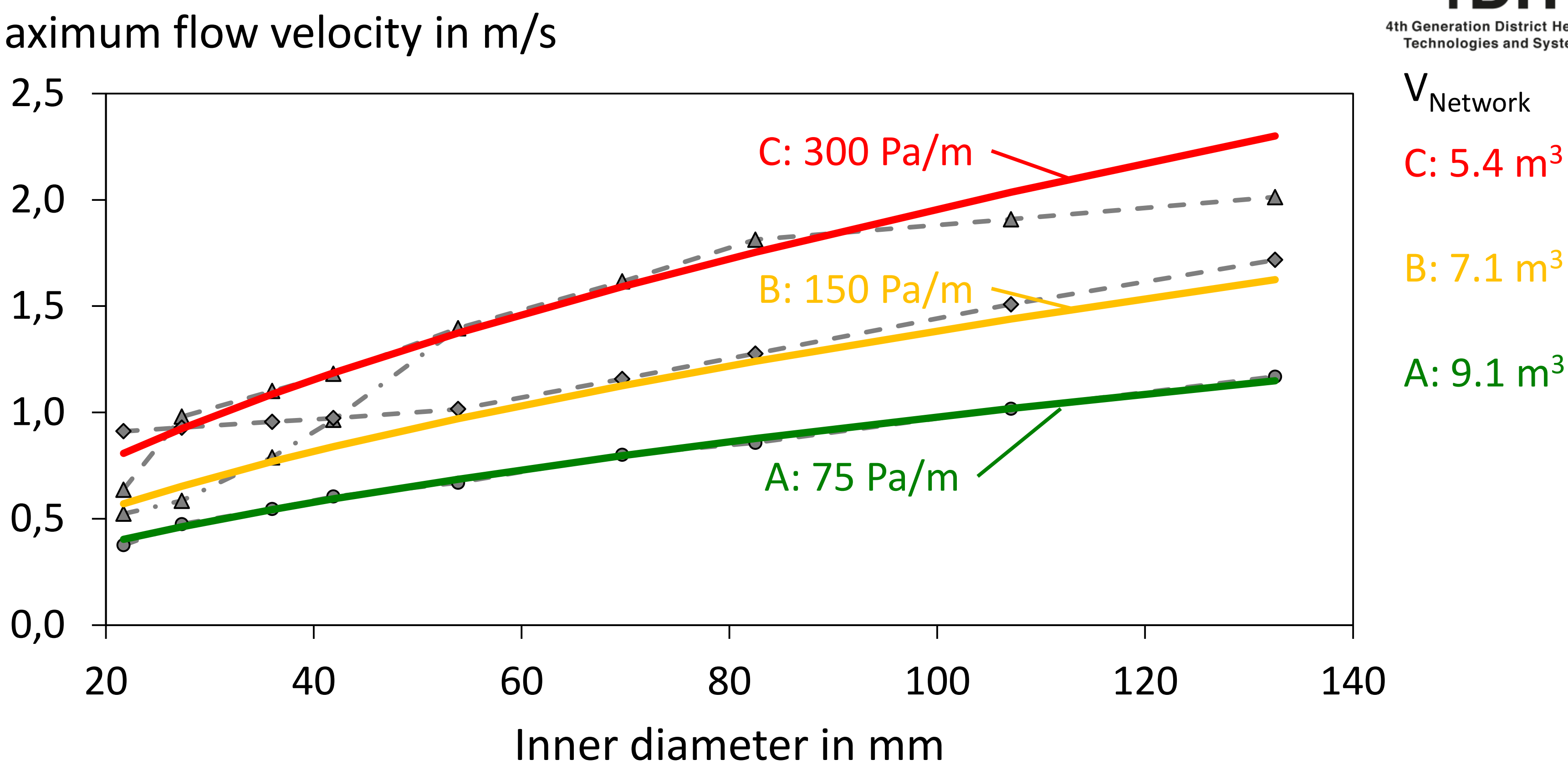


Detailed STANET-Simulation model:

- Twin pipes, standard insulation
- Fixed return temperatures
- Controlled bypasses at branch endpoints maintain 60 °C
- Annual simulation, timestep 1 h

3 Design variants:

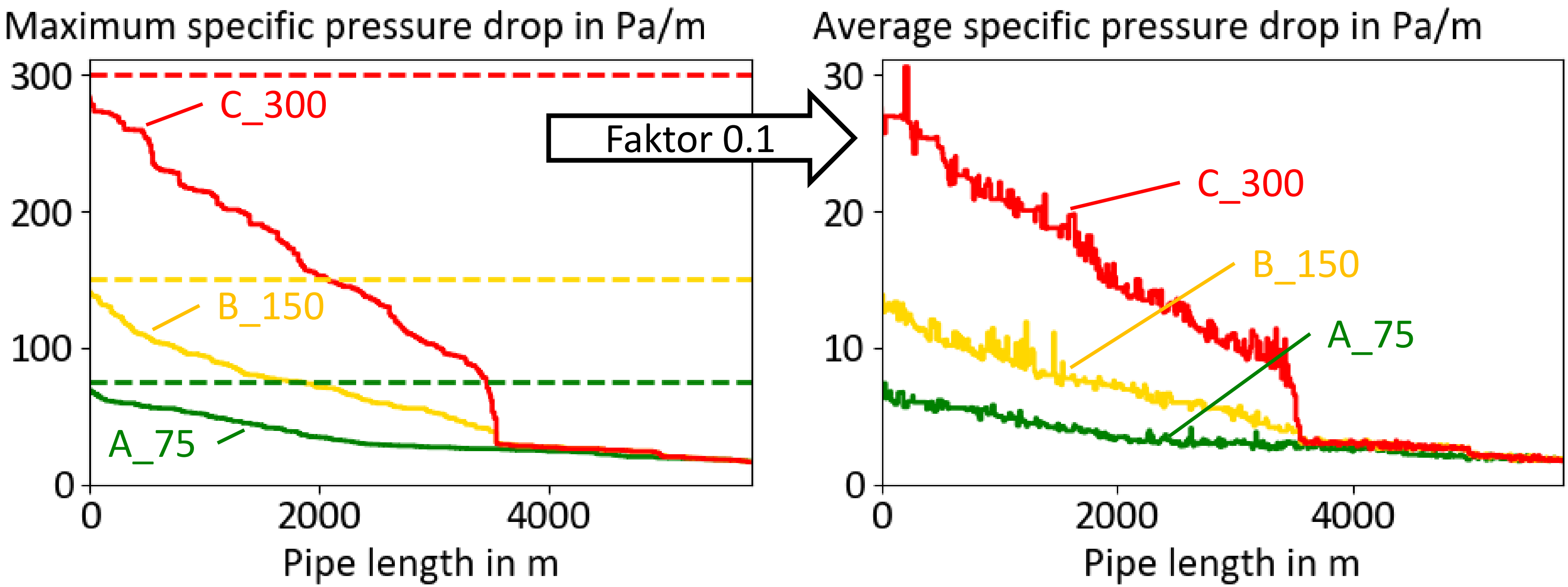
75, 150, and 300 Pa/m



A→C: Network volume reduced by 40 %

Results:

Low pressure drops



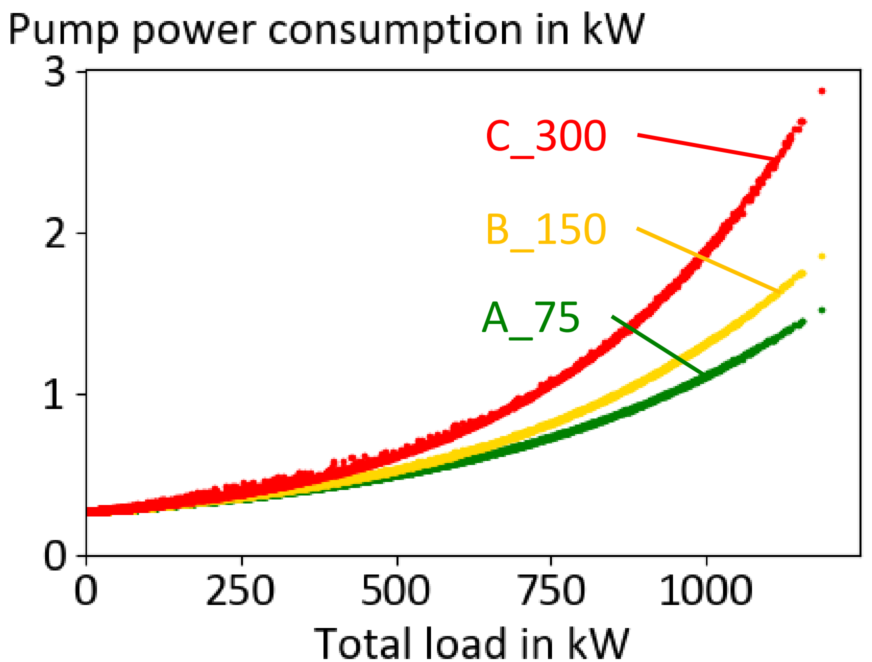
→ **Max. pressure drop on average only 40 % of design value**

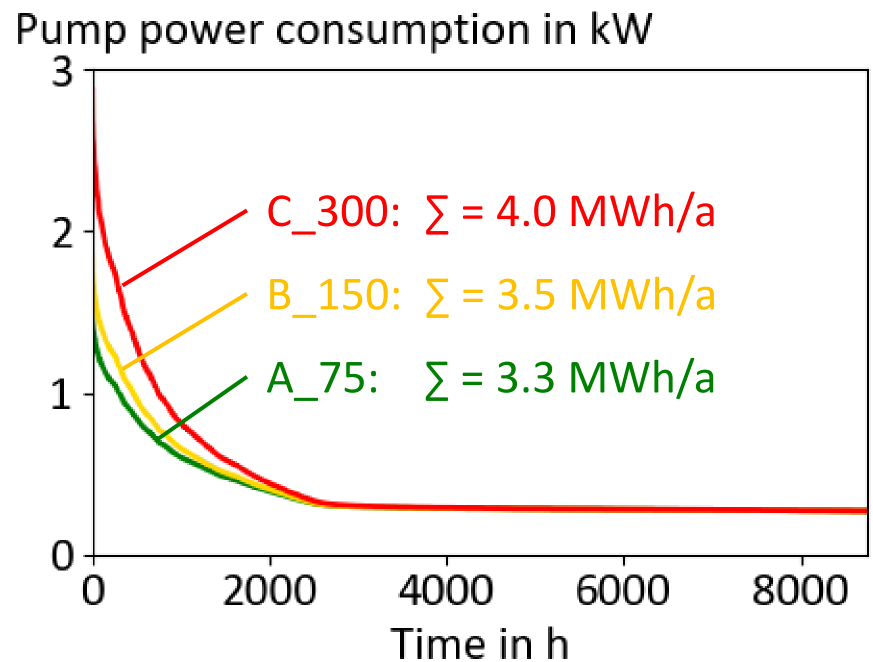
→ **House lead-in pipes oversized (restricted to DN20)**

→ **Annual average pressure drop is 10 times smaller**

Results:

Pump energy increases moderately



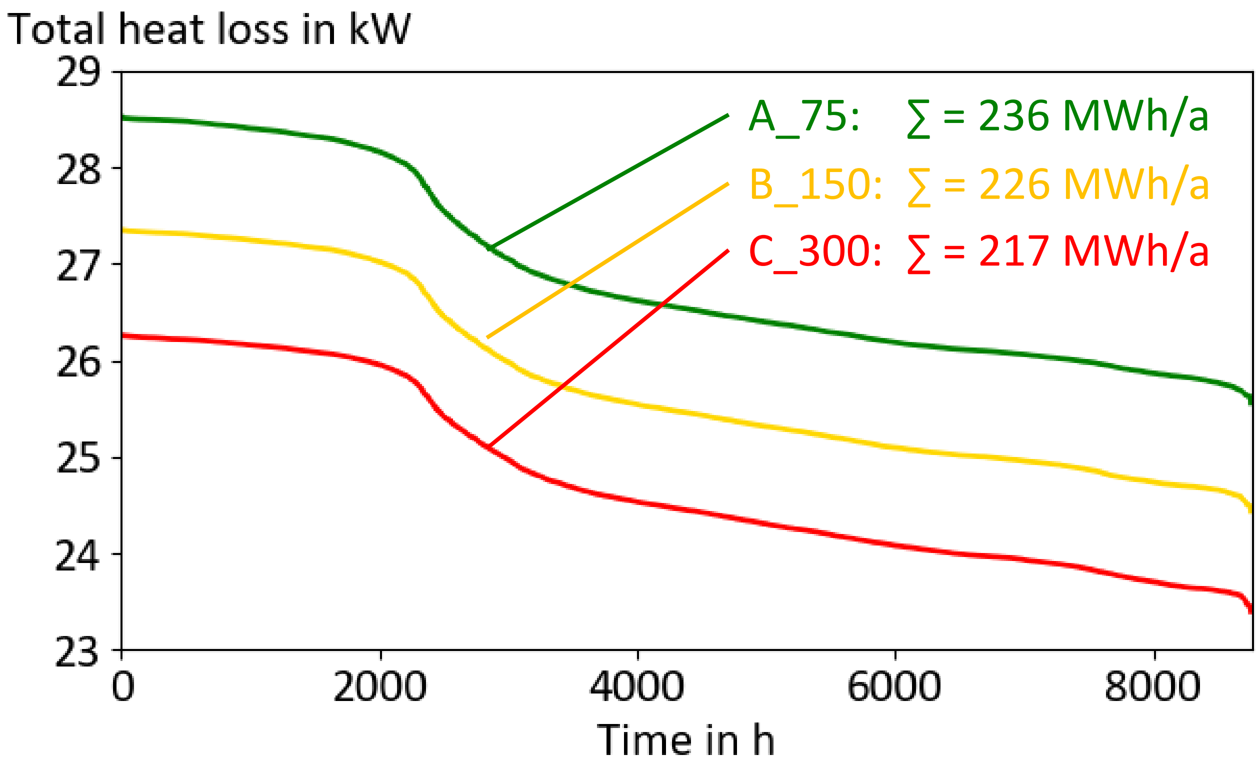


A→C: Maximum pump power almost doubled

A→C: Pump energy demand increases by only 20 % due to dominance of the low load period

Results:

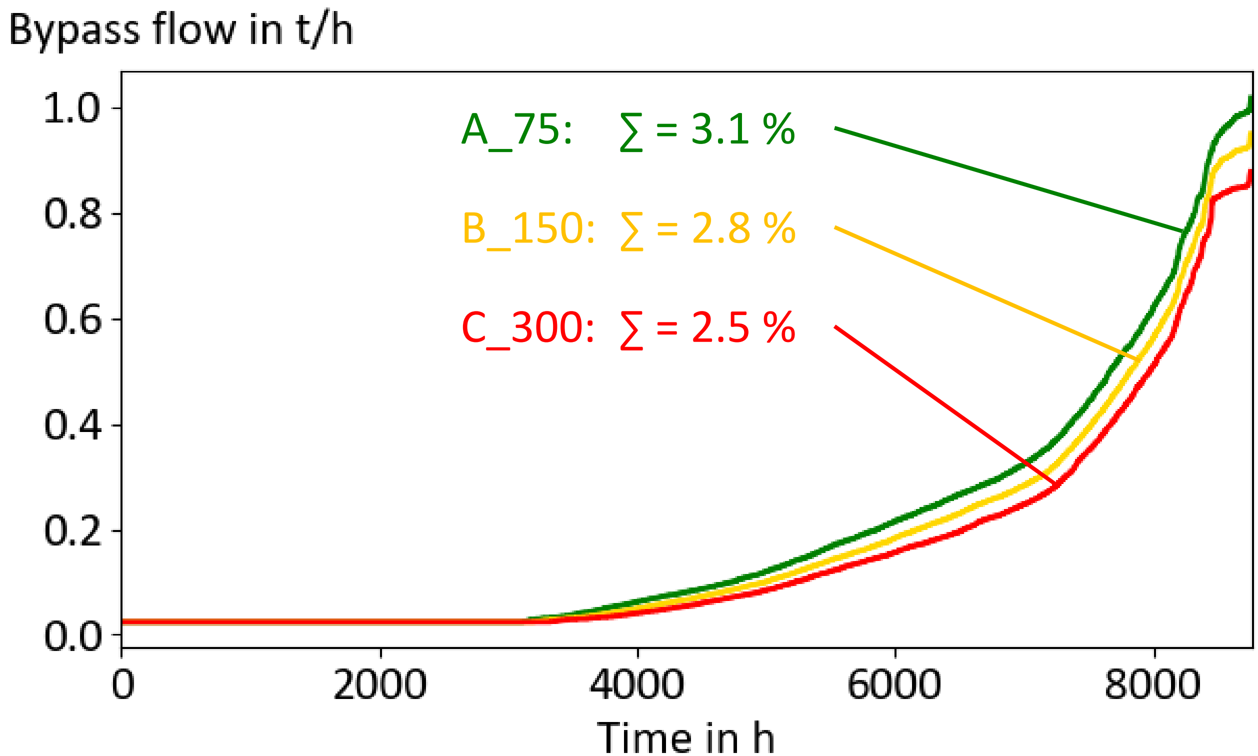
Heat losses decrease



A→C: Reduction of heat losses by 8 % due to reduced pipe diameters

Results:

Reduction of bypass flows

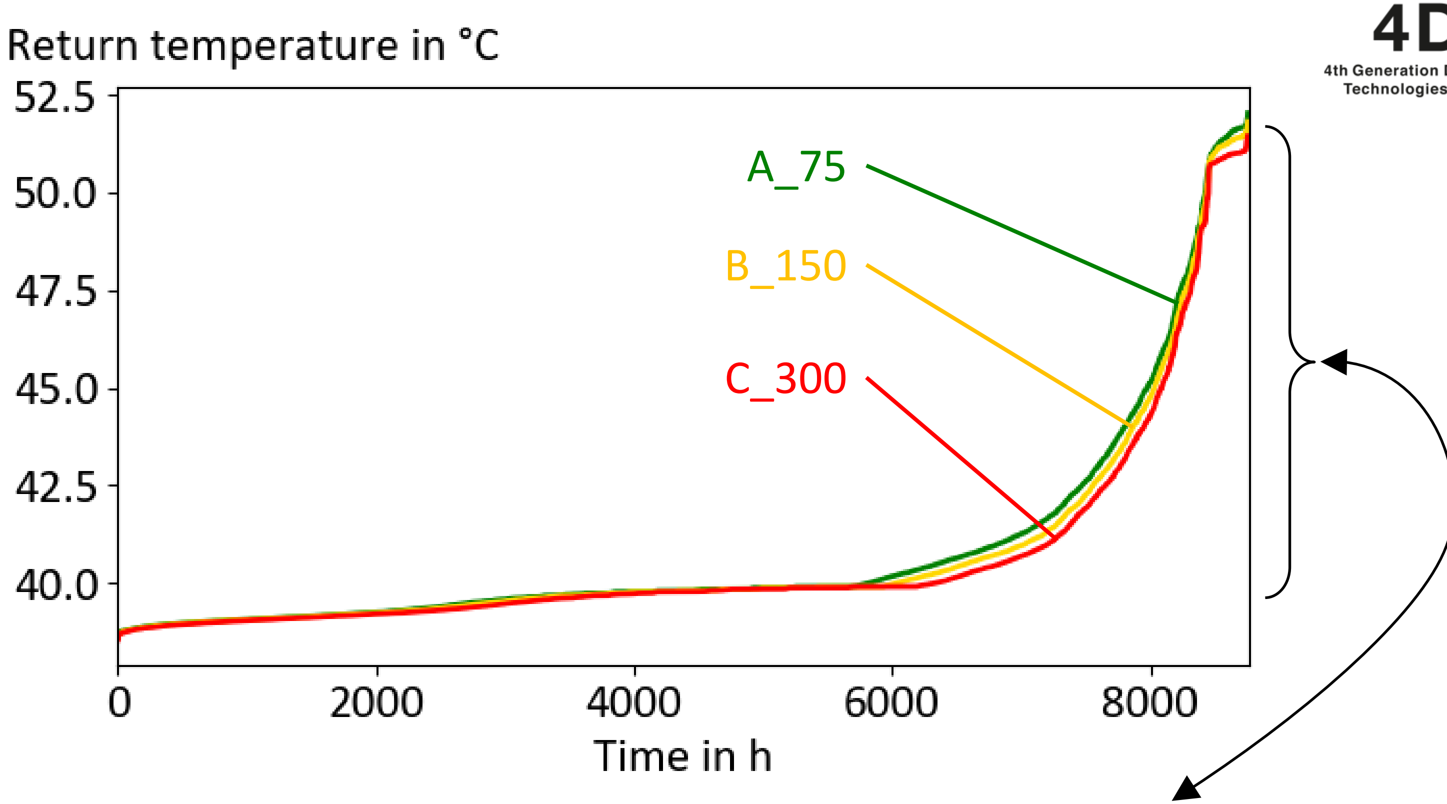


A→C: Bypass flows during 60 % of the year (3 % of total flow)

A→C: Reduction of bypass flows by 18 % due to less temperature degradation in smaller pipes

Results:

Impact of bypass flows on return temperature



A, B & C: Return temperature contamination up to 12 K in summer

A→C: 0.2 K lower return temperature over the year due to less bypass flows at smaller pipe diameters

Results: Overview

Measure	Unit	A_75	B_150	C_300	Trend A→C
Δp_{max}	bar	0.87	1.07	1.80	↗ +107 %
W_{pump}	MWh/a	3.30	3.48	3.97	↗ +20 %
Q_{loss}	MWh/a	236	226	217	↘ -8 %
$\dot{m}_{\mathrm{bypass}}$	%	3.1	2.8	2.5	↘ -18 %
$\bar{T}_{\mathrm{return}}$	°C	40.8	40.7	40.6	↘ -0.2 K

Conclusion

Design for high specific pressure drops up to 300 Pa/m

…has positive effects on thermo-hydraulic performance

…does not entail unfavourably high pressures and pump energy demands

Thank you for your attention!
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