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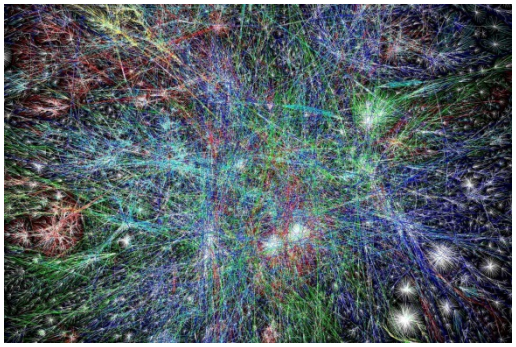

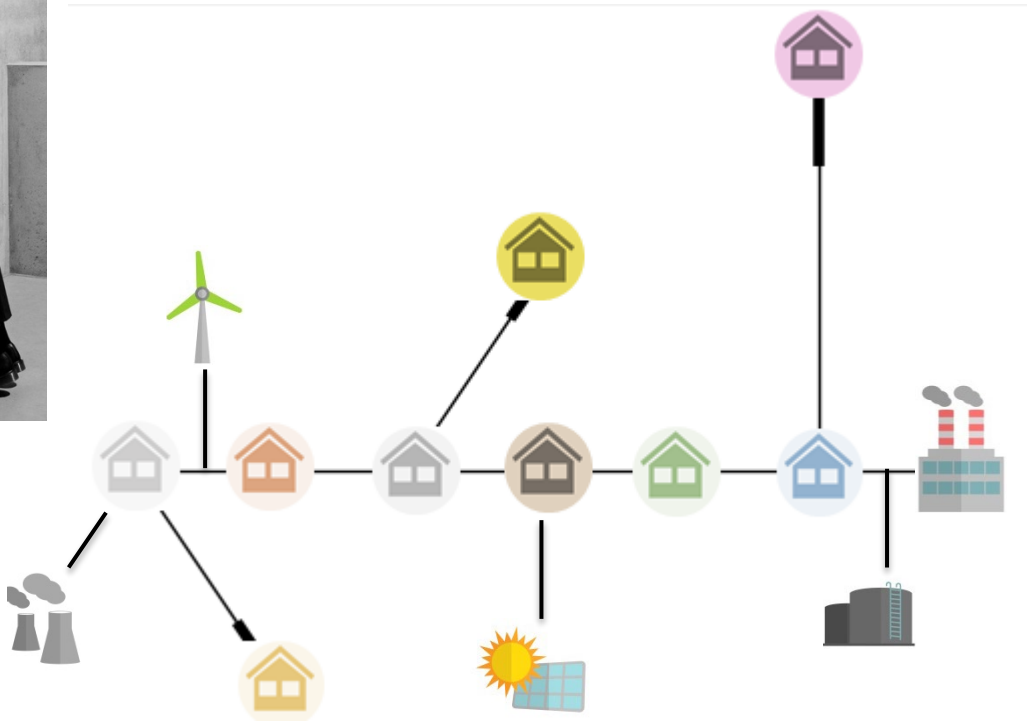

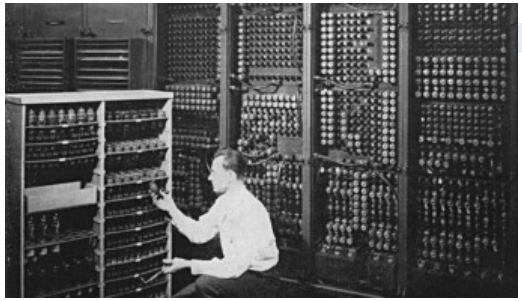

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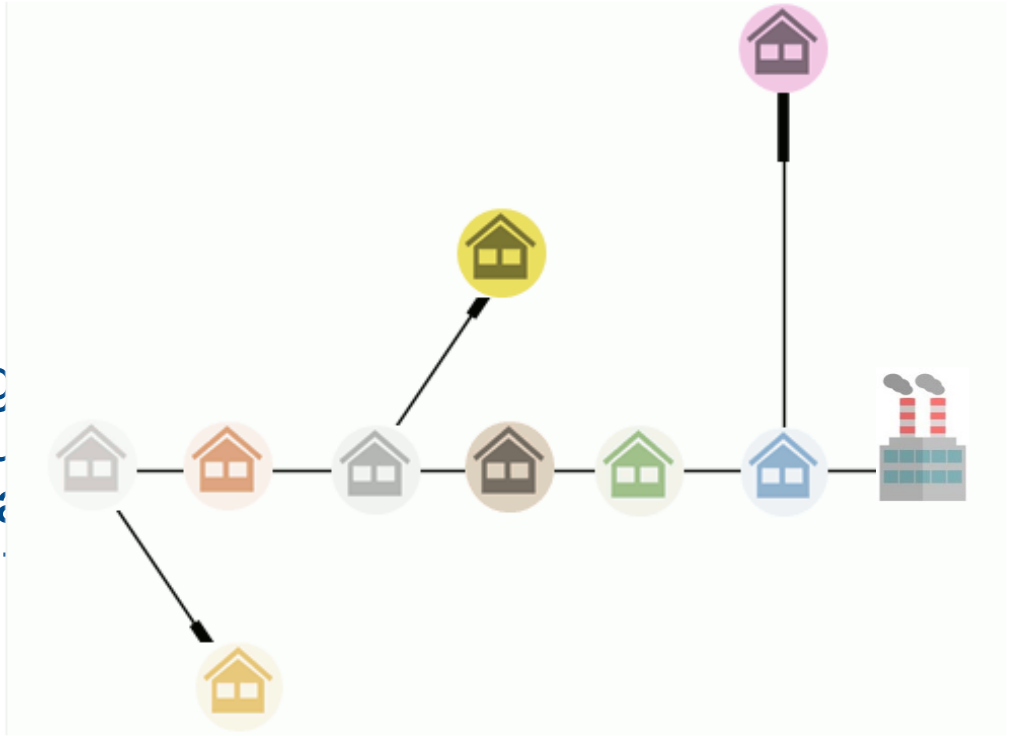
Enabling
and redu
heating a
aggrega



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Aggregation Process

How to prove:

- Delay
- Mass Flow
- Heat Load
- Heat Loss from Supply and Return Pipe
- Pressure Drop

$$d_A = 2\sqrt{\frac{A_A}{\pi}} = 2\sqrt{\frac{\beta(1+\alpha\psi)A_1A_2}{A_2 + A_1\alpha^2\psi}}$$

$$D_A = d_A\sqrt{1+\left(\frac{\rho^W c^W}{\lambda^P F^P}\right)\left(\frac{1-\varphi_A}{\varphi_A}\right)}$$

$$\text{If } \theta^Y_2 \geq \alpha \leftrightarrow H^Y_2/H^Y_1 \geq m_2/m_1$$

$$H^Y_1 = (1+\alpha)H^Y_B$$

$$H^Y_2 = H^Y_1 - \alpha H^Y_B$$

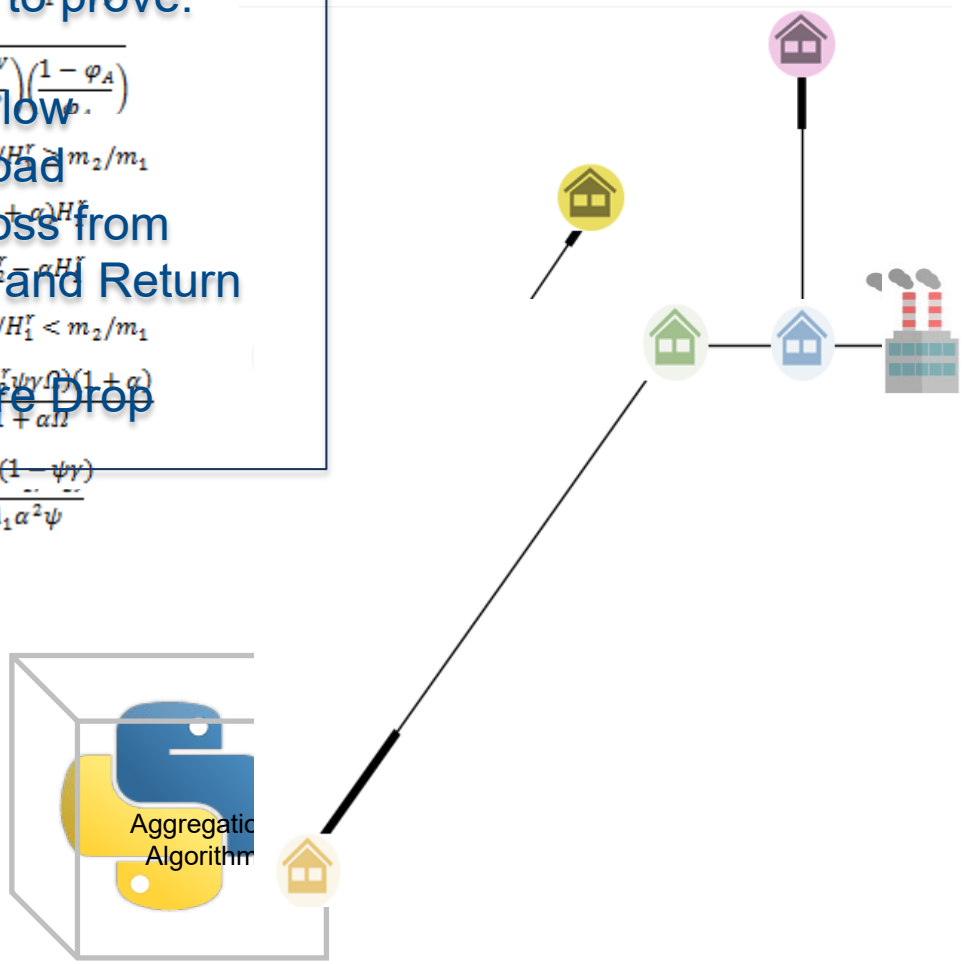
$$\varphi$$

$$\text{If } \theta^Y_2 < \alpha \leftrightarrow H^Y_2/H^Y_1 < m_2/m_1$$

$$H^Y_A = \frac{(H^Y_1 + H^Y_2\psi\gamma\Omega)(1+\alpha)}{1+\alpha\Omega}$$

$$H^Y_B = H^Y_2(1-\psi\gamma)$$

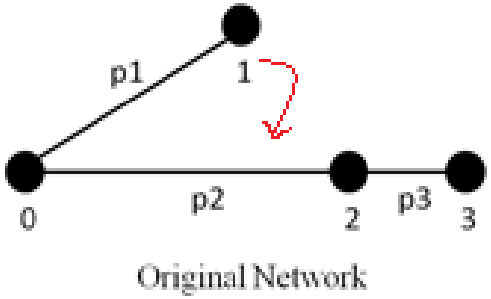
$$L_A = L_1\frac{}{A_2 + A_1\alpha^2\psi}$$



Aggregation aims for:

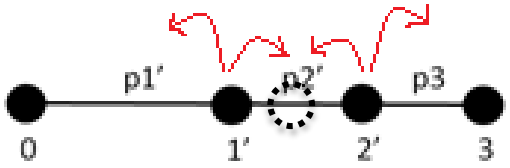
✓ Reduction of the network topology

The Danish Aggregation Method

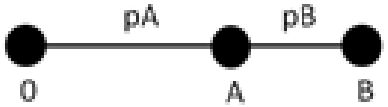


Original Network

$$\tau_{pipe1} < \tau_{pipe2}$$

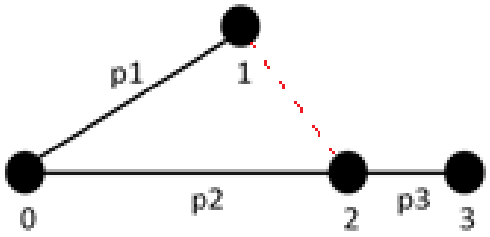


Equivalent Network

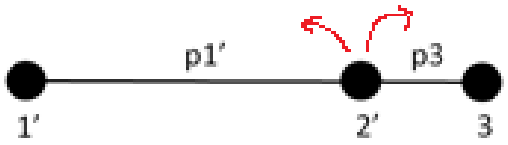


Reduced Network

The German Aggregation Method



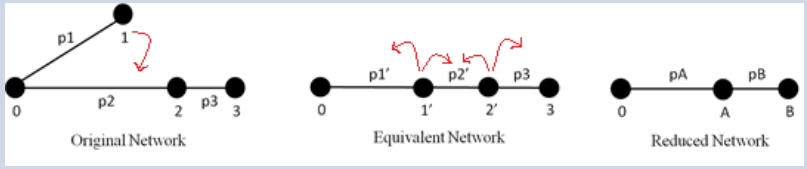
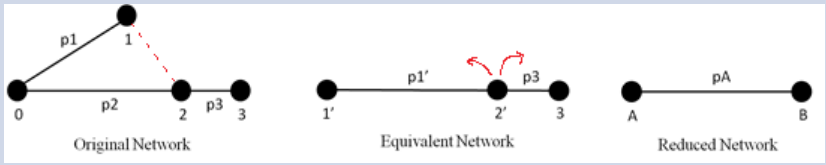
Original Network

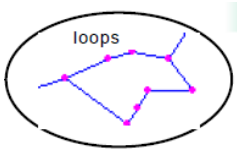


Equivalent Network

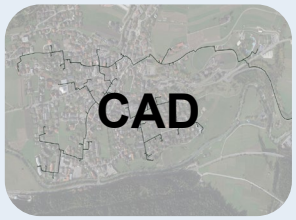
Reduced Network

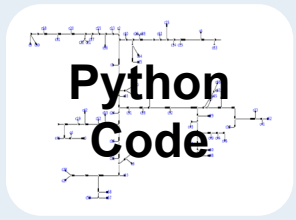
Comparison of these methods

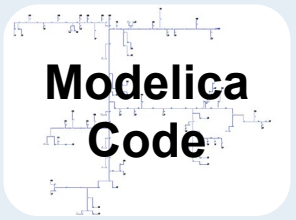
The Danish Method	The German Method
	
➢ Can not handle loops ➢ Ends up as line network ➢ Pressure drop is not considered ➢ Information on supply and return pipes heat loss seperately	➢ Supports loop ➢ Ends up in a line/tree structure ➢ Pressure drop is considered ➢ Information on total heat loss



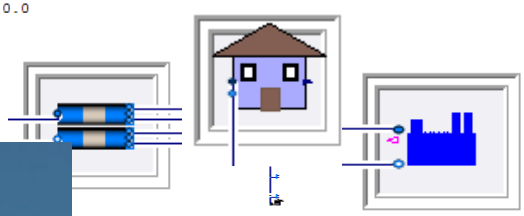
The Workflow

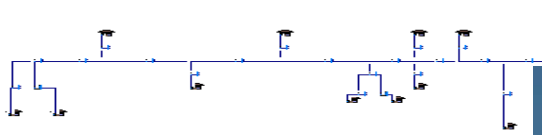


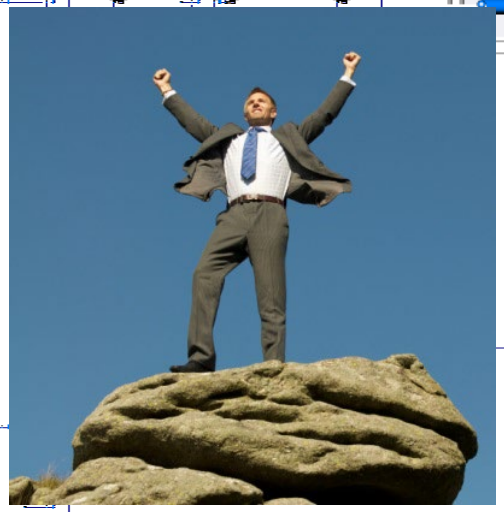




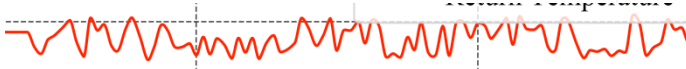

```
Producer Prod0(m_flow_nominal=20, pressureDiff=50000.0, nodeControl=nodeControl, redeclare
     package Medium =                                                              Medium,
    MaxHeatFlow=10000000,
    m_flow_min=0.0001,
    Tsupply=273.15 + 88)
;
 Consumer C3(alpha=[0.0, 0.0, 1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
     package Medium =
```

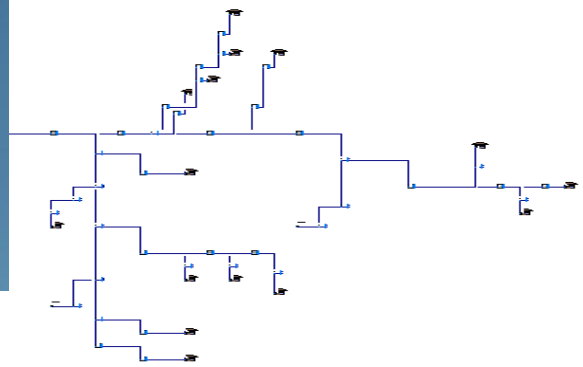


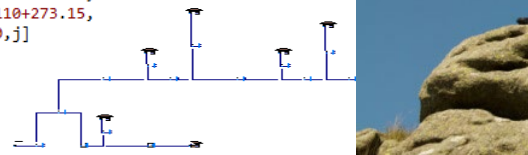


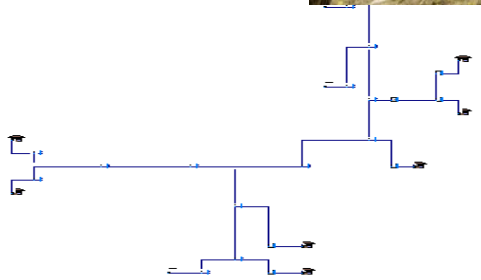


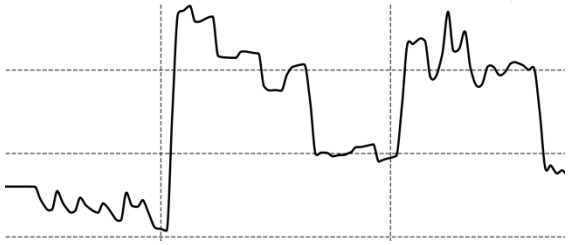
```
net.add_producer('Prod',
                 {
                  'm_flow_nominal': 20,
                  "pressureDiff":0.5e5,
                  'pos' : [i,j],
                  'Tsupply' : 273.15+68,
                  'p_before':'O.port_a.p',
                  'p_after':'O.port_b.p',
                  'maxHeatToWater': 6e6,
                 })
net.add_customer('C3',
                 {
                    'T_in_min': 60 +273.15,
                    'T_in_max': 110+273.15,
                    'pos' : [i-40,j]
                 \\
```



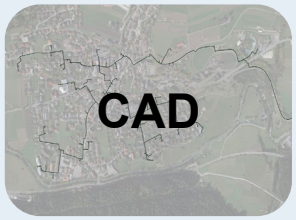


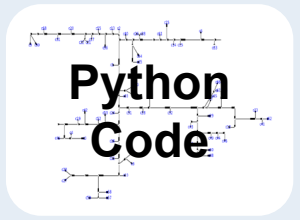


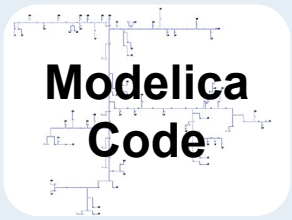


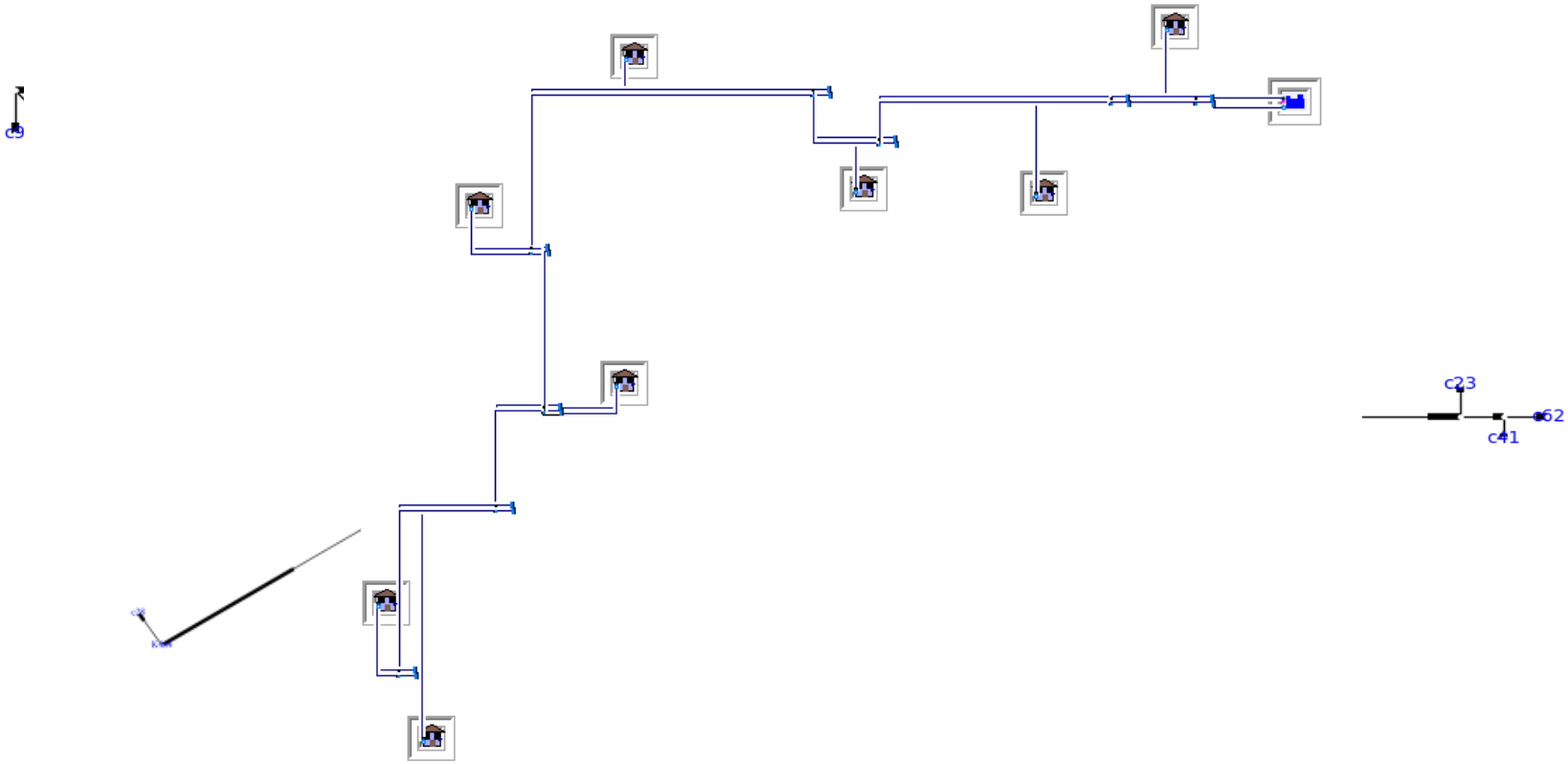


The Workflow

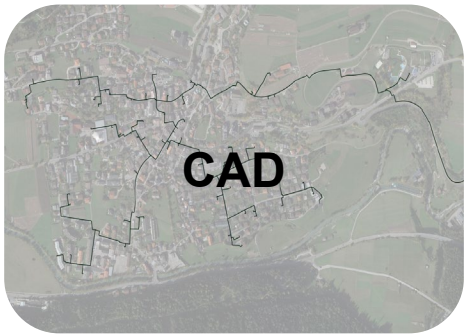


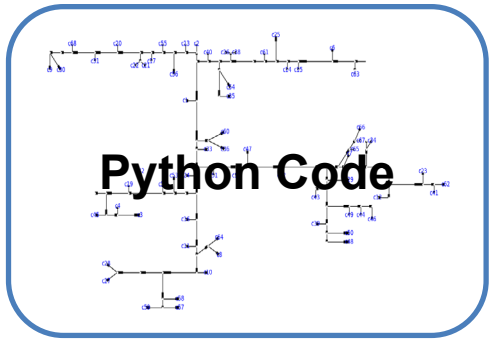


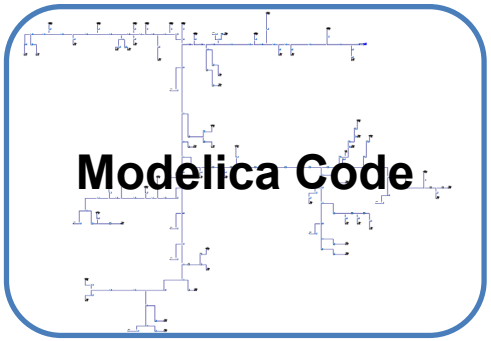




Are you still with me ?

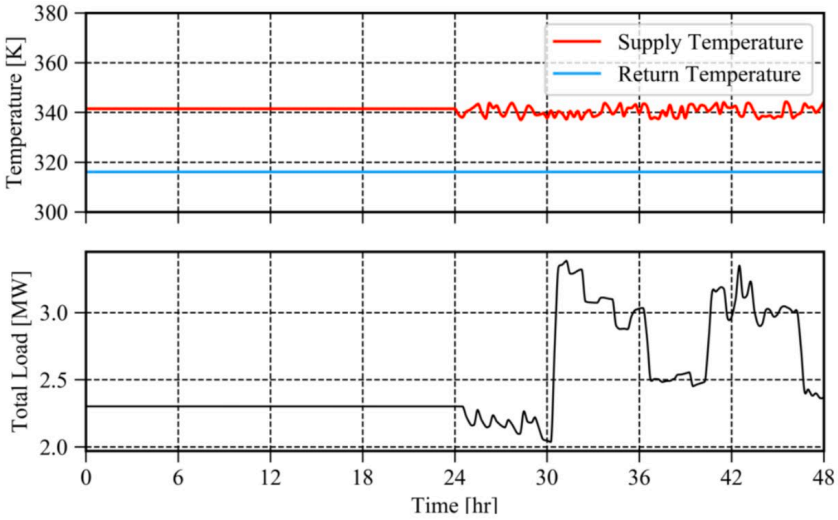






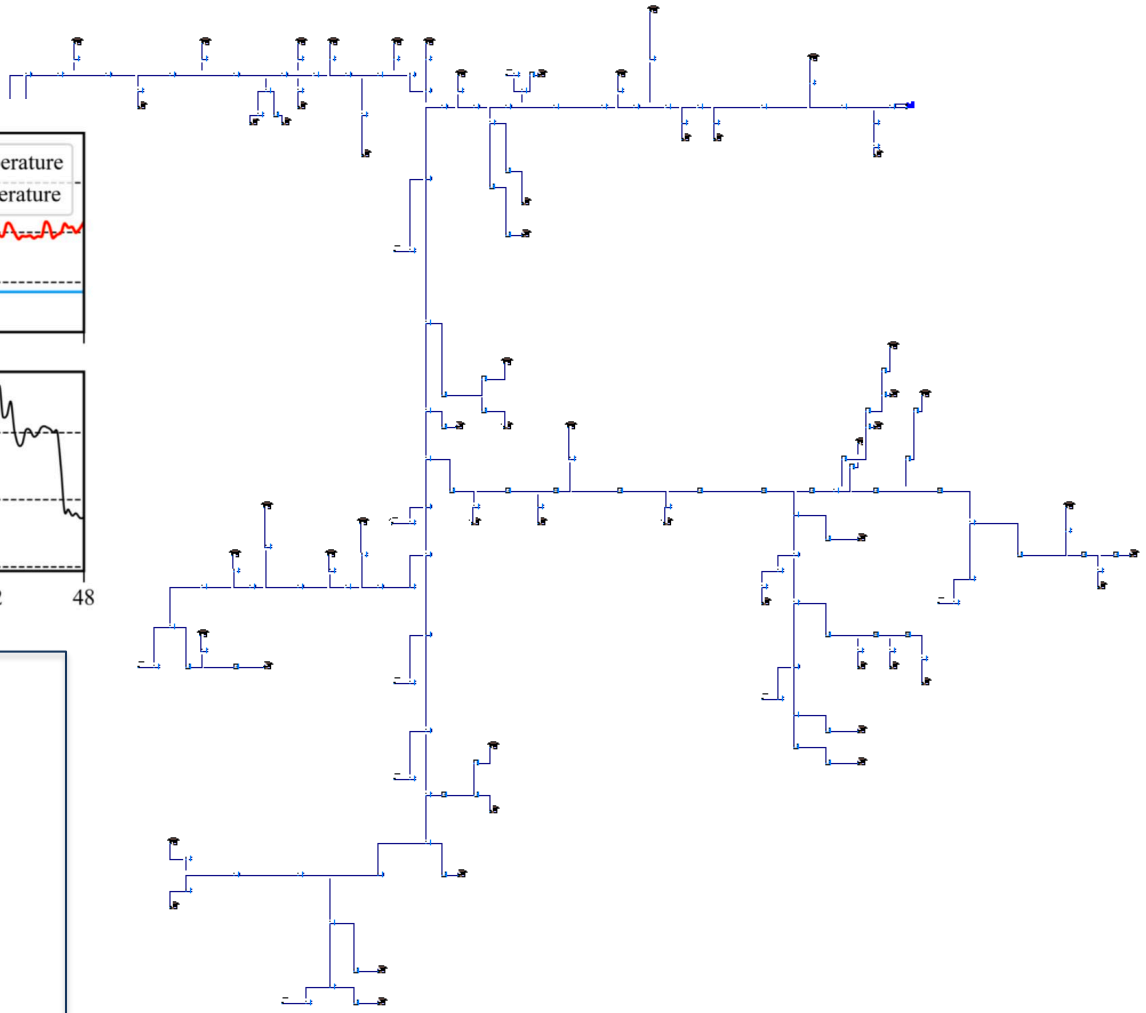
Existing network with 146 consumers and 1 production unit ~7 km

Inputs

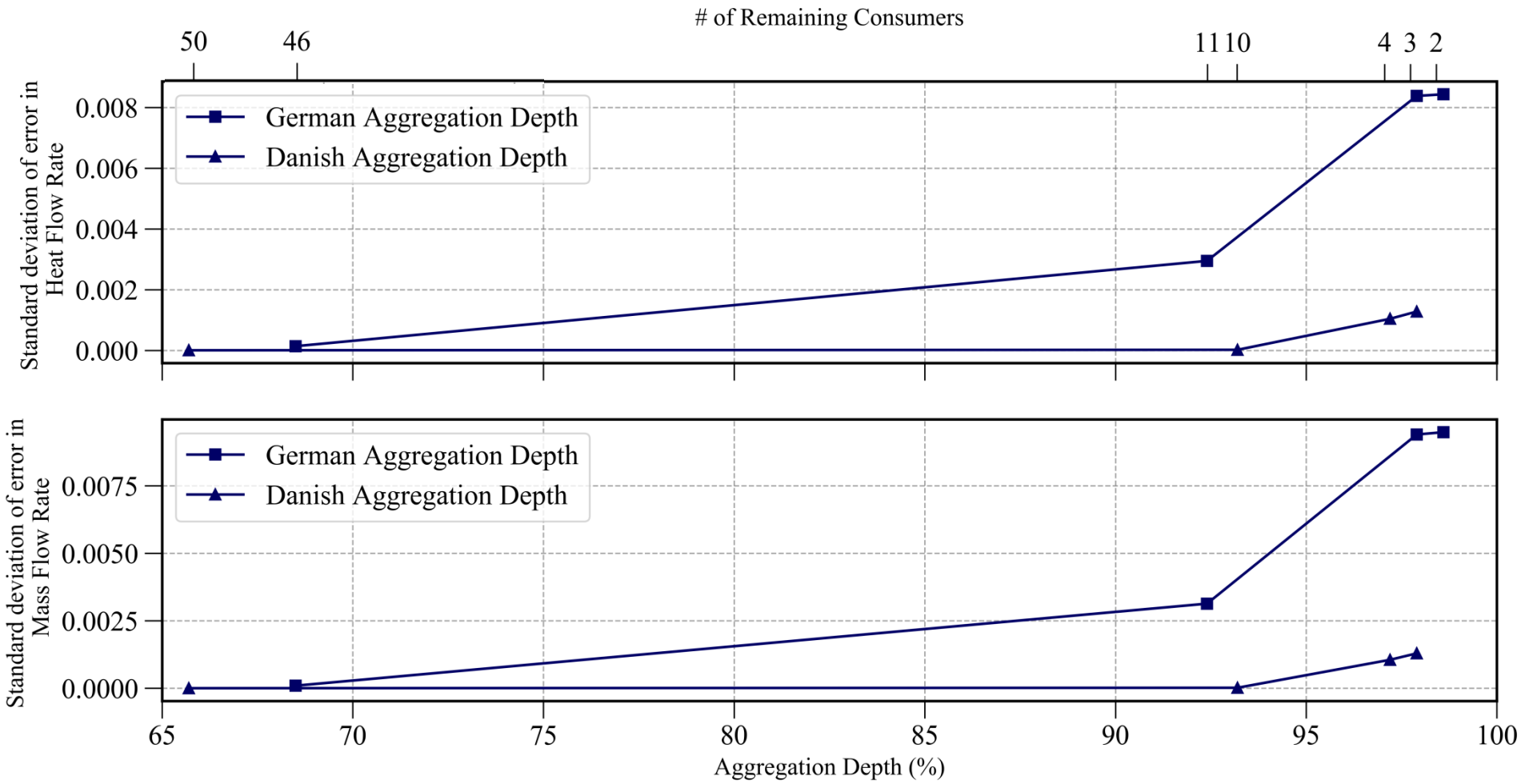


How to prove:

- Delay
- Mass Flow
- Heat Flow
- Heat Loss from Supply and Return Pipe
- Pressure Drop



What is accurate ?
Danish: %93
German: %69



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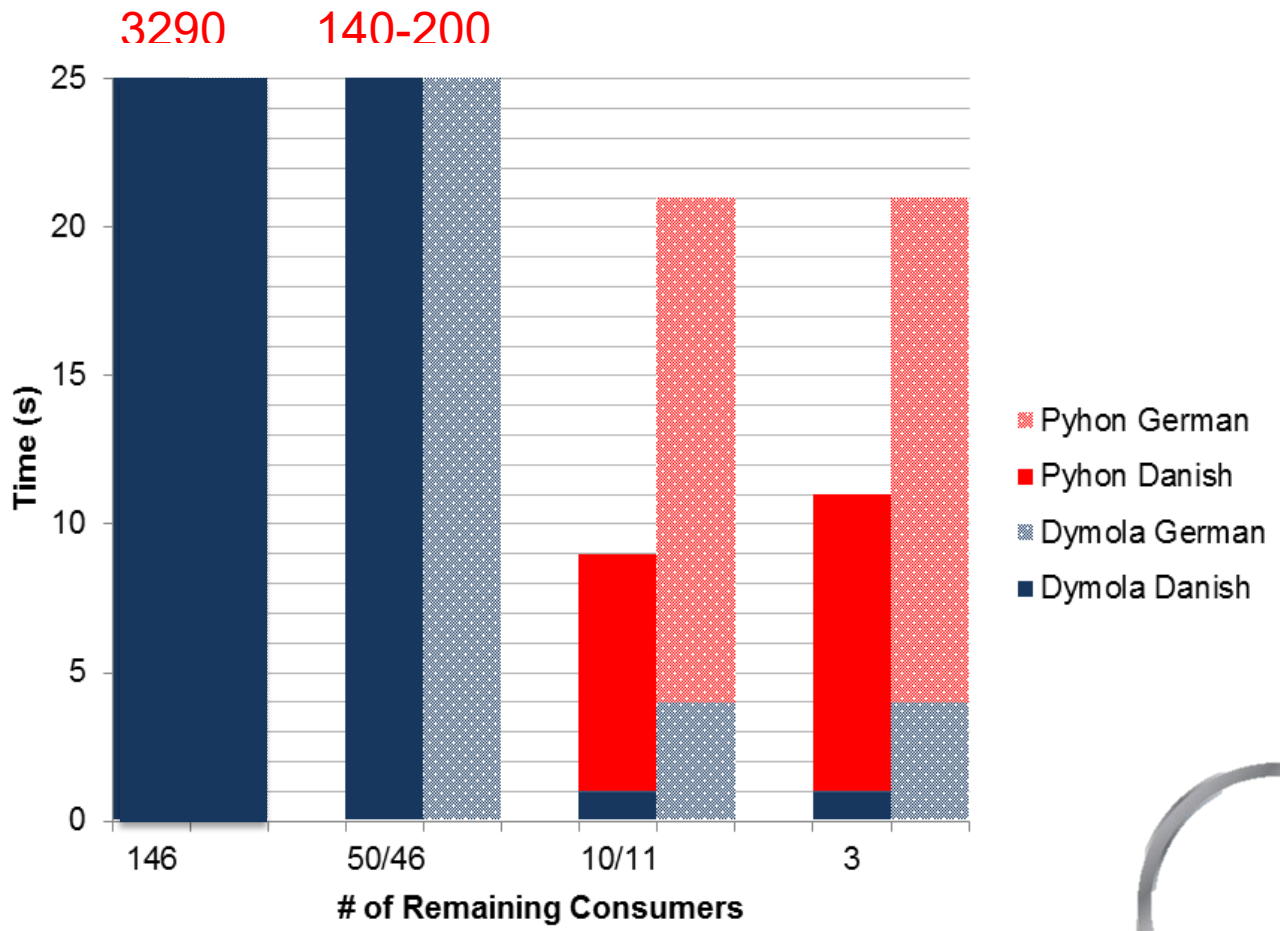
146 consumers: ~ 3300 (sec)
50 consumers: ~200 (sec)
3 consumers: ~20 (sec)



And the Oscar goes to …..

German %69
Network with 300 consumers
Aggregated network 90 consumers
146 consumers, 2 weeks, 15 min interval simulation: 1hr

Renewable Heating and Cooling in Integrated Urban and Industrial Energy Systems

#ISEC2020 - a Forum for Research, Business and Energy Policy

Topics and Call for Papers: January 2020

14th - 16th October 2020

Congress Graz, Austria

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IDEA TO ACTION

Thank you !

References

H. V Larsen and H. F. Ravn, *Equivalent models of district heating systems for on-line minimization of operational costs of the complete district heating system*, no. 1323. Department of Energy Engineering Technical University of Denmark, RISØ National Laboratory Systems Analysis Department, 1999.

B. Bøhm *et al.*, “Simple models for operational optimisation,” *IEA Dist. Heat. Cool. Annex 6*, no. Report April 2002: S1, pp. 1–151, 2002.

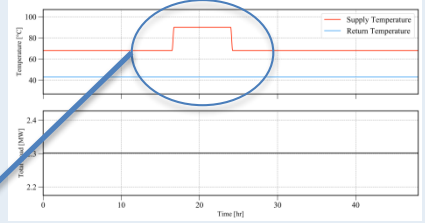
H. V. Larsen, H. Pálsson, B. Bøhm, and H. F. Ravn, “Aggregated dynamic simulation model of district heating networks,” *Energy Convers. Manag.*, vol. 43, no. 8, pp. 995–1019, 2002.

H. V. Larsen, B. Bøhm, and M. Wigbels, “A comparison of aggregated models for simulation and operational optimisation of district heating networks,” *Energy Convers. Manag.*, vol. 45, no. 7–8, pp. 1119–1139, 2004.

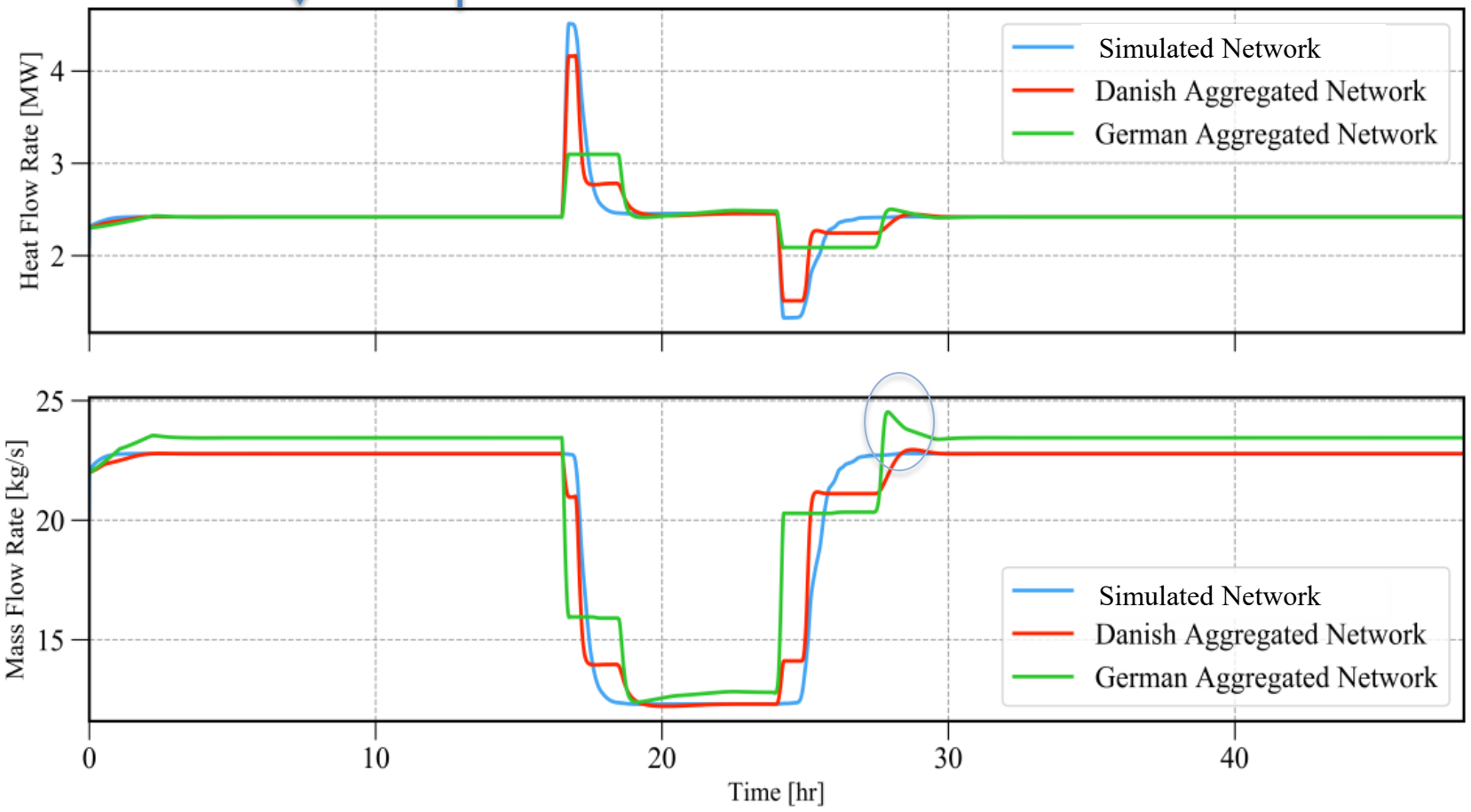
Possible Questions

- All of the simulations are run on a laptop with 6 GB RAM and four 2.4 GHz CPUs.
- In Dymola, integrator properties are selected Radau IIa as an integration algorithm and 10^{-07} as tolerance.
- All simulations are run at least 5 times and the averages of the simulation times are taken into comparison.
- Why Modelica ? Acasual (no analytical transformations, in Modelica manual scripting and computational order are avoided), we have a internal library
- We calibrated our network

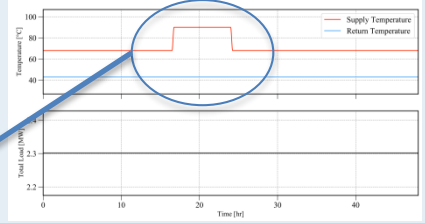
Comparison with 3 consumers

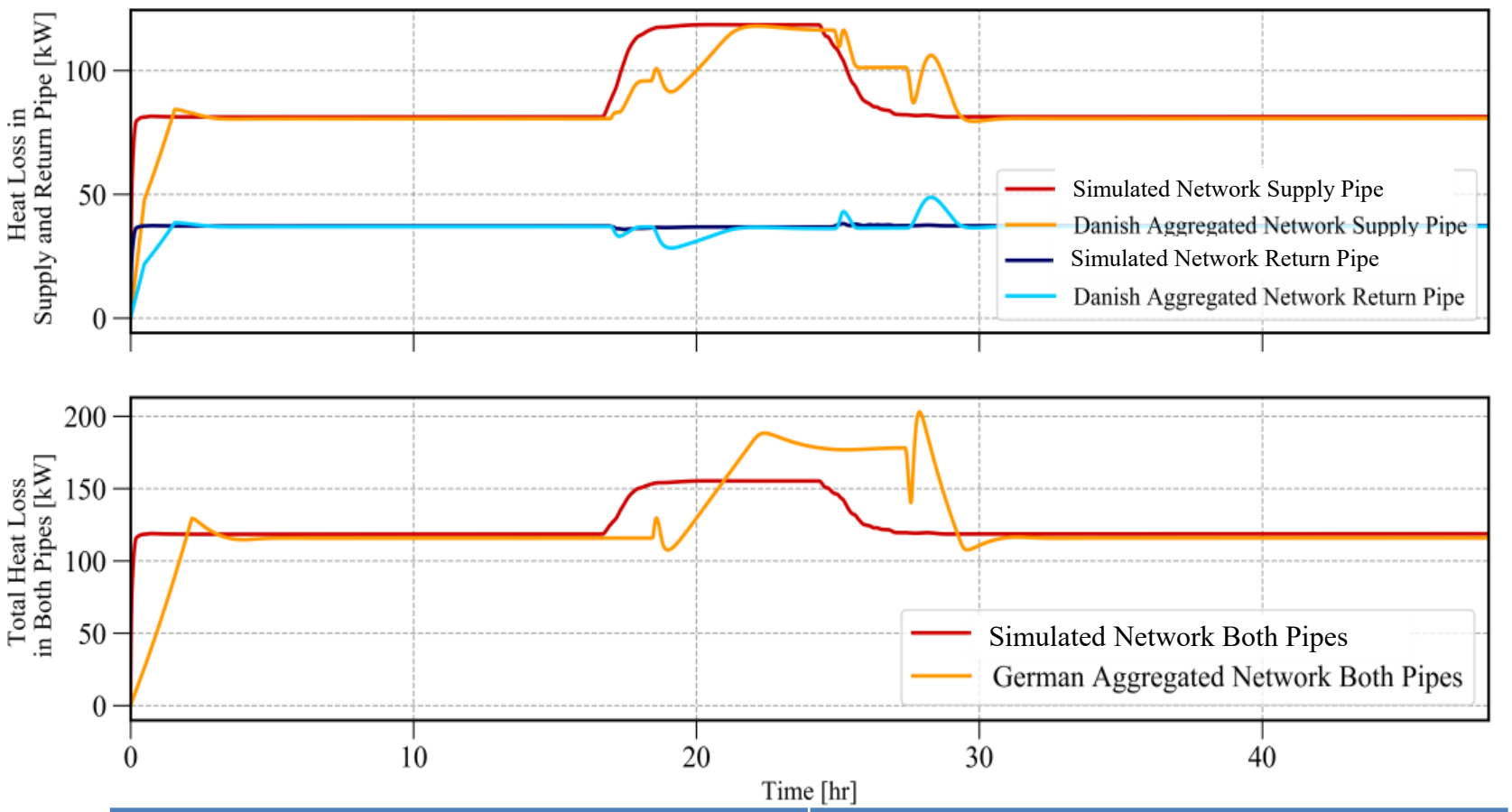


$$q = mC_p\Delta T$$



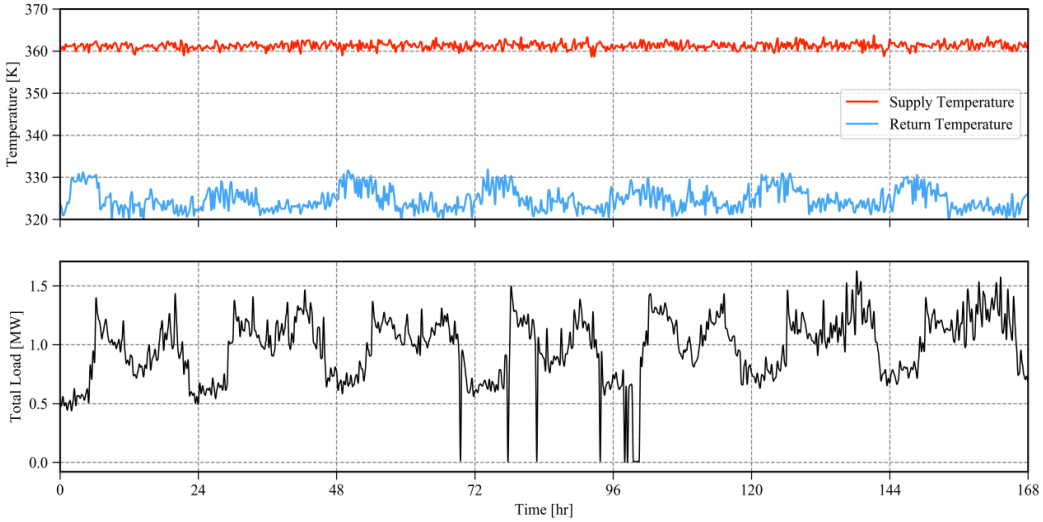
Comparison with 3 consumers

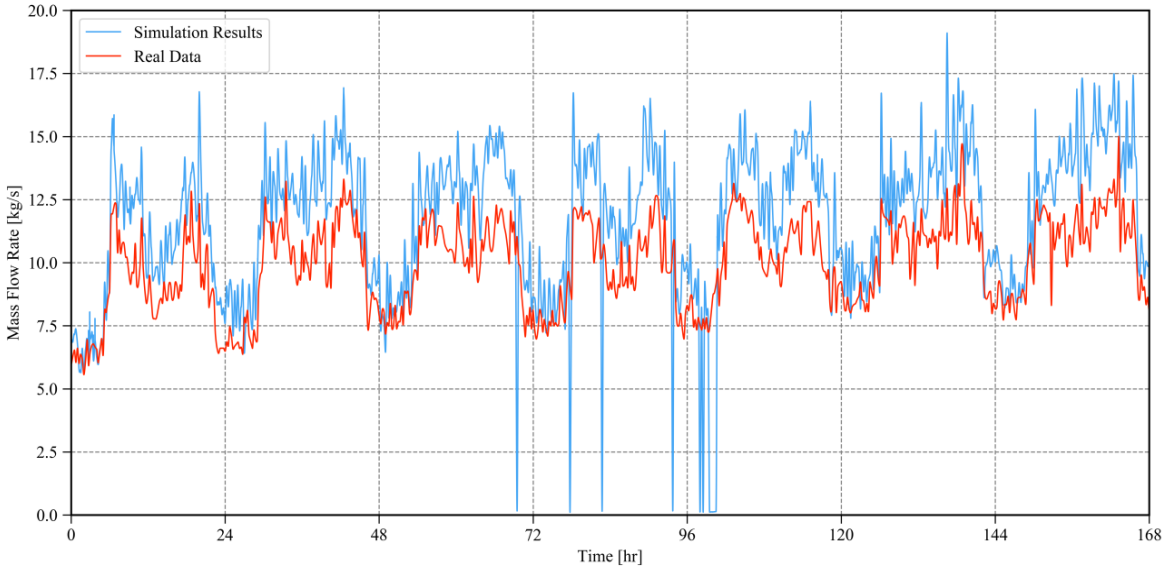


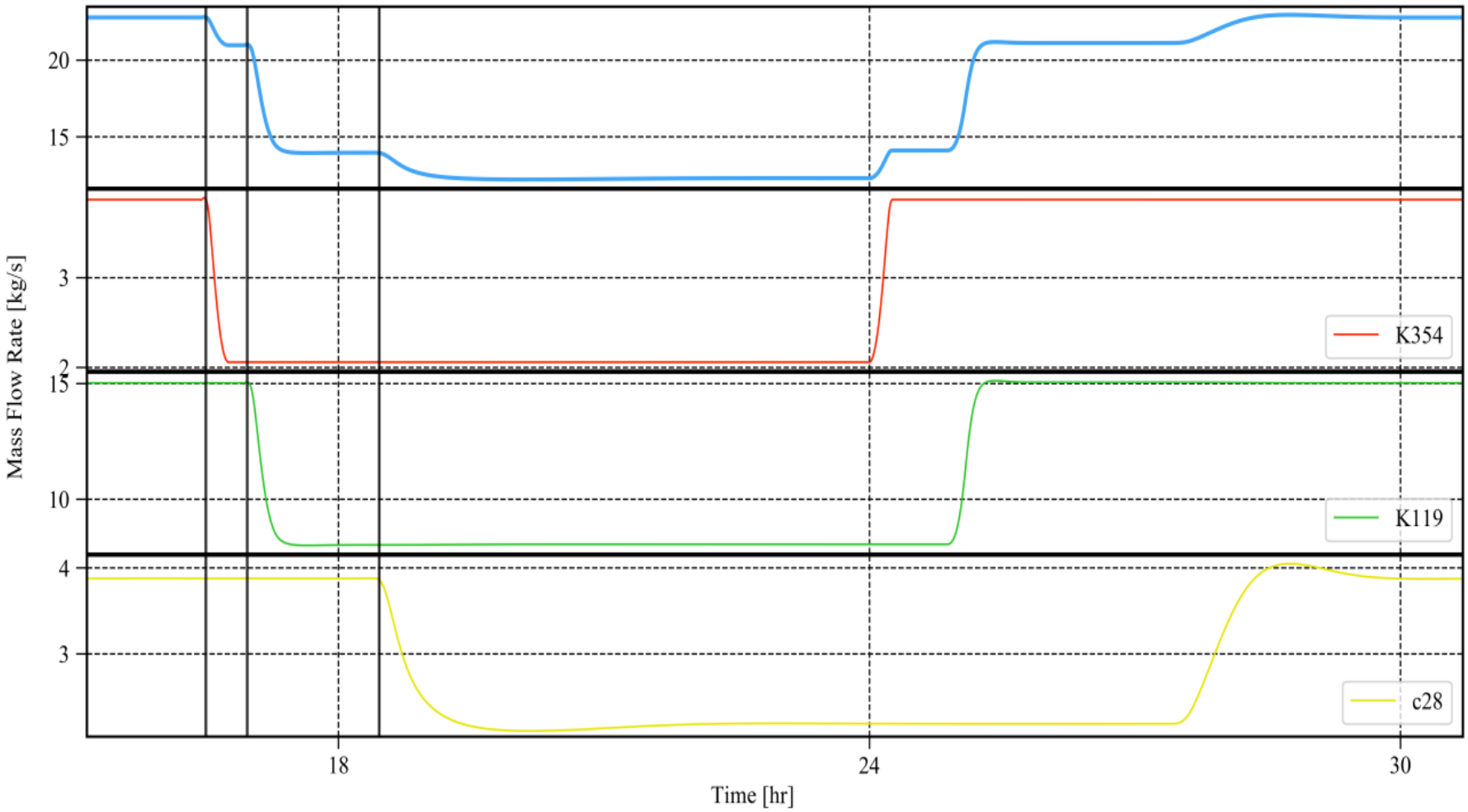


The Danish Method	The German Method
➢ Information on supply and return pipes heat loss seperately	➢ Information on total heat loss

1 week simulation
inputs: Supply and return temperature profiles, load profiles






Mass Flow Rate [kg/s]
20
15
3
2
15
10
4
3
K354
K119
c28
18
24
30
Time [hr]