Automated model generation and simplification for district heating and cooling networks

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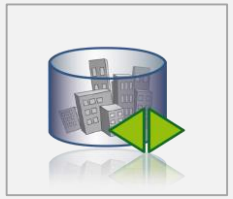
Use Case

- Where are we using DHC network simulations?
  - Large research center in Germany
  - 102 substations
  - 37 km network length
  - Heating and cooling
  - Very meshed network topology

Workflow description

Data

GIS Data
OpenStreetMap
Graph Data



- 3D City Database
  - Nodes
  - Edges
  - Pipe description

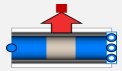
Export

Python

Model Generation
&
Simplification

uesgraphs

uesmodels

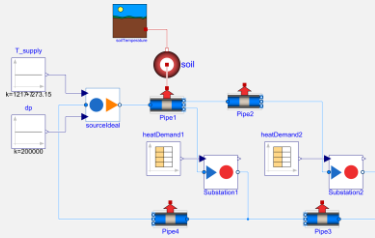


- Graph based interaction
  - Simplification
  - Parametrization

Export

Modelica

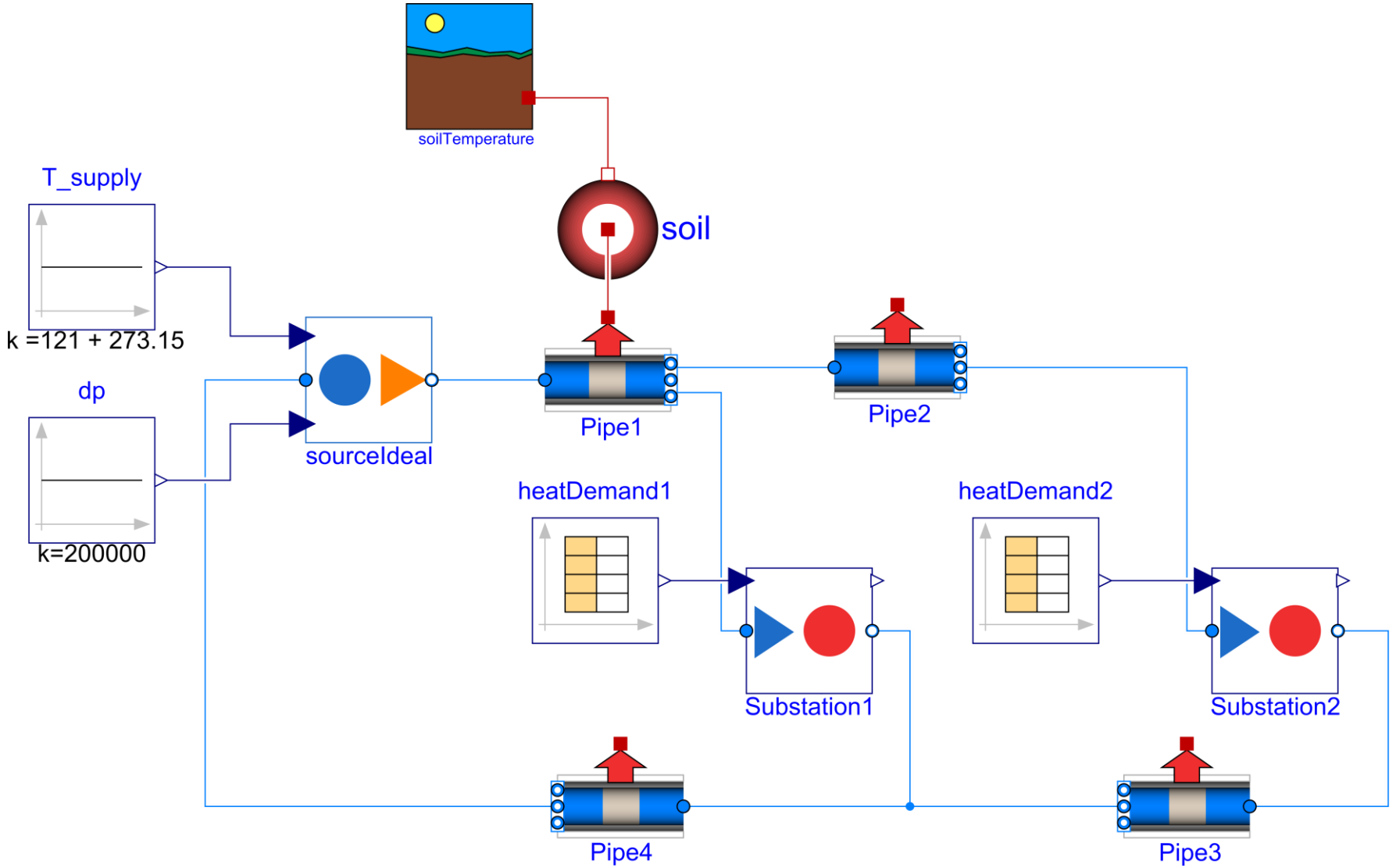
Simulation Model



- Simulation
  - Dymola

Model Description - Substation

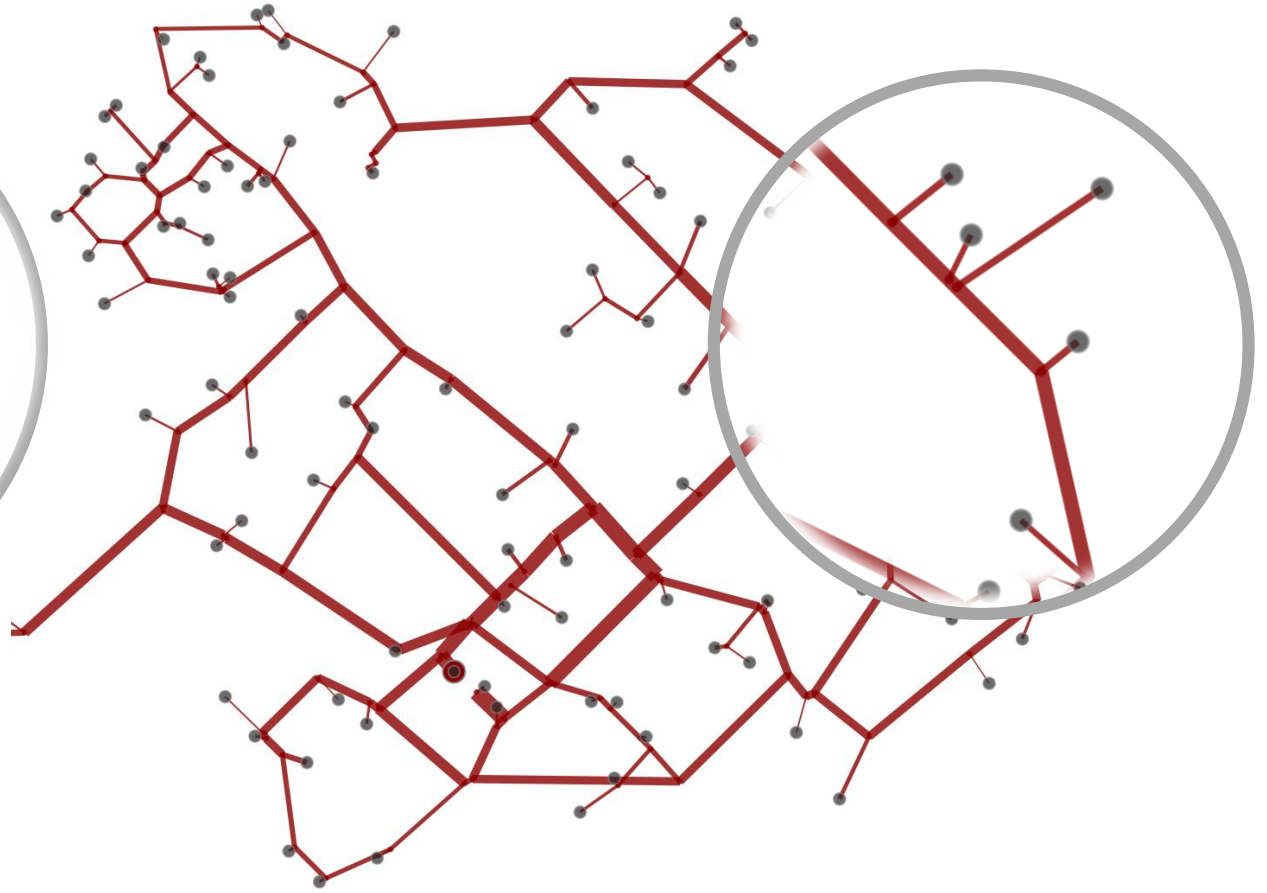
- AixLib Substation
  - Heat demand flow control
  - Fixed return temperature
  - Open-loop



Model simplification – topology reduction

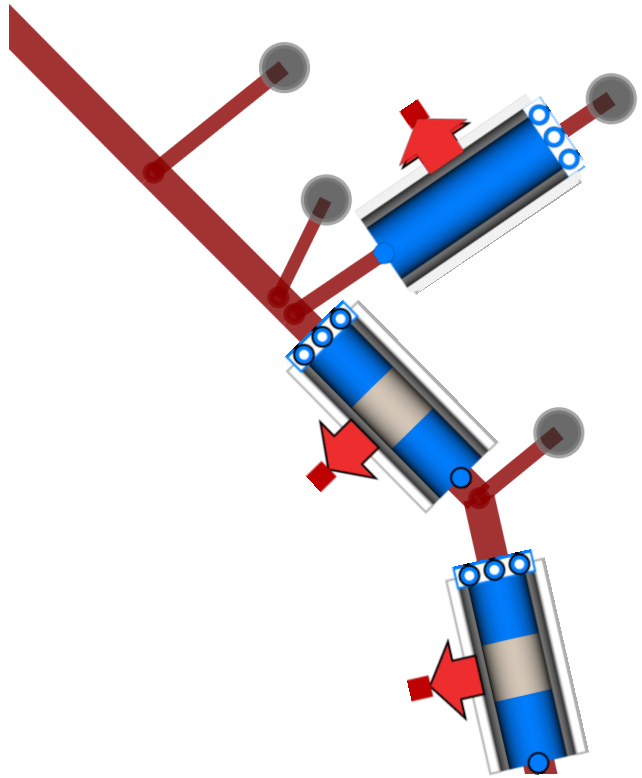
- Original graph properties:
  - Number of nodes: 2986
  - Number of edges: 3001
- Simplified graph properties:
  - Number of nodes: 252
  - Number of edges: 267
- Merged parameters:
  - Edgelength
  - Diameters
  - Insulation

Model simplification – topology reduction



Model simplification – Pipe model reduction

- Pipe model simplification:
  - Replacement of plug-flow pipes with static pipes
  - Investigation of the pipe length and flow velocity on the temperature propagation
  - 59 pipes got replaced with shorter then 20m (260 pipes in original model)



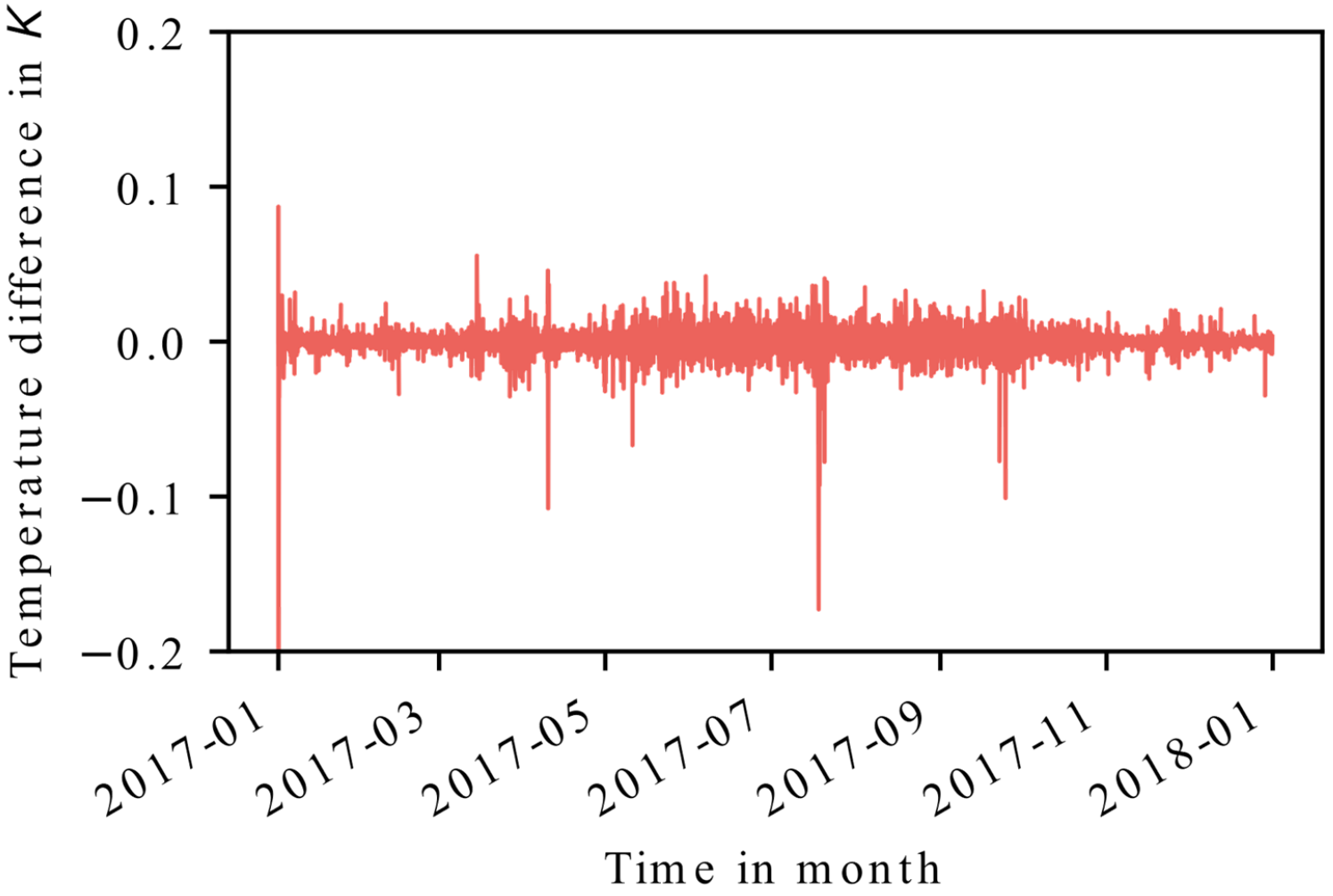
Results - KPIs

- Simplification results on simulation statistics
  - High decrease of simulation time
  - Pipe replacement reduces the components for 2 per pipe
  - Decrease of state events
  - Slight difference in overall heat supply

Results	Plug-flow Model	Reduced Model
Simulation Time	32.5 h	17.8 h
Number of Components	15475	15357
Number of state events	13551	10162
Overall heat supplied	82.7 GWh	82.6 GWh

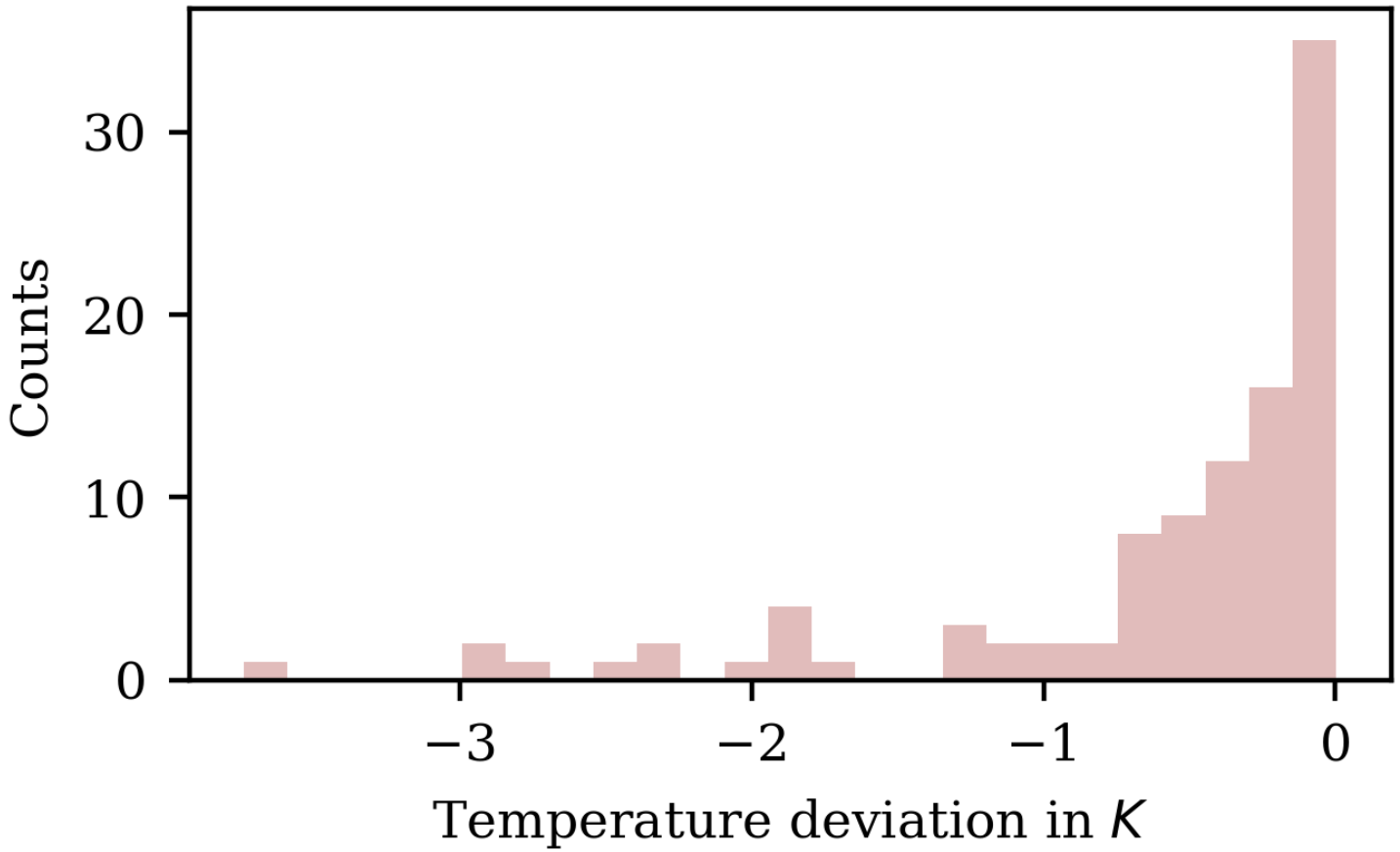
Results - Comparision

- Return temperature difference at supply
  - Fluctuating behavior between + / – 0.2 K



Results - Comparision

- Average flow temperature difference at all substations
  - A few substations show a higher average deviation
  - The majority of deviations are between -1 K and 0



Summary and Next Steps

- Presentation of a two step simplification approach for district heating and cooling networks
  - Topology reduction leads to a complexity reduction while merging all necessary thermal and hydraulic information
  - Pipe model reduction leads to a reduction of the simulation model complexity
    - Significant reduction of simulation time
    - Good accordance to plug flow modelling approach

- Modelica is capable of large scale district heating and cooling network simulations and provides a platform for the investigation of advanced control strategies

- Next steps:
  - Improving the overall system by a closed-loop integration
  - Detailed comparison to measurement data
  - Analyzation of numeric impact

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