3RD INTERNATIONAL CONFERENCE ON

SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING

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AALBORG UNIVERSITY
DENMARK

THERMAL SYSTEMS SIMULATION

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Integration of time delays in an agent-based controller: a simulation case study

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Context

Time delays in district heating and cooling networks

- Become more important with a more dynamic control
- But are difficult to handle!

Goal

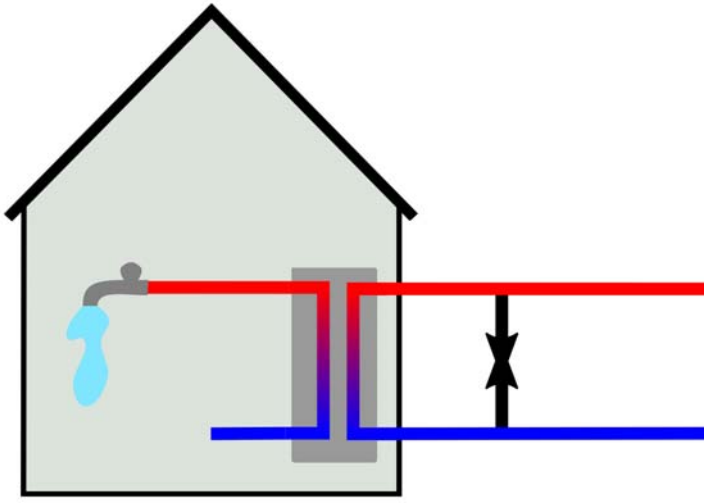
- Illustrate the importance of time delays in control problems

- Show difference in performance of different bypass control principles
  - Constant mass flow
  - Thermostat controlled bypass
  - Predictive control of bypass that makes use of time delays

Bypass

Ensures thermal comfort: fast delivery of warm water to the customers

Mostly used in summer



Downsides:

- Increasing return temperature:
  - Increased supply temperature
  - Increased mass flows

Consequences:

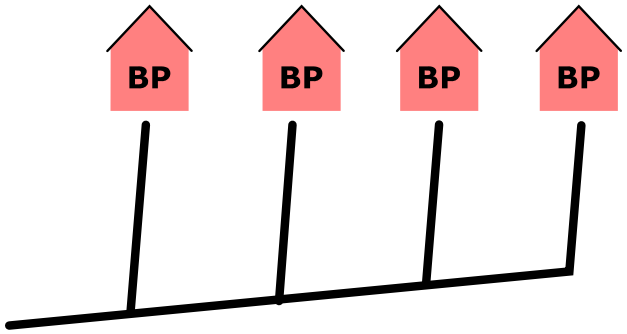
- Heat losses increase
- Less efficient heat generation
- Increased pump energy

Bypass control principles

- **Constant mass flow**
- Thermostat control
- Predictive control

- Used in older networks
- Easy, but inefficient

Bypass is always turned on.



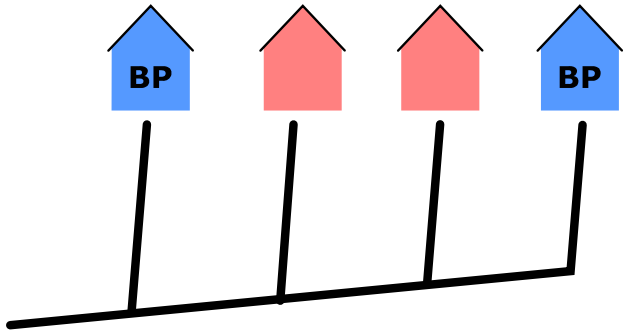
Bypass control principles

- Constant mass flow
- **Thermostat control**
- Predictive control

- Used in newer networks
- Hysteresis control

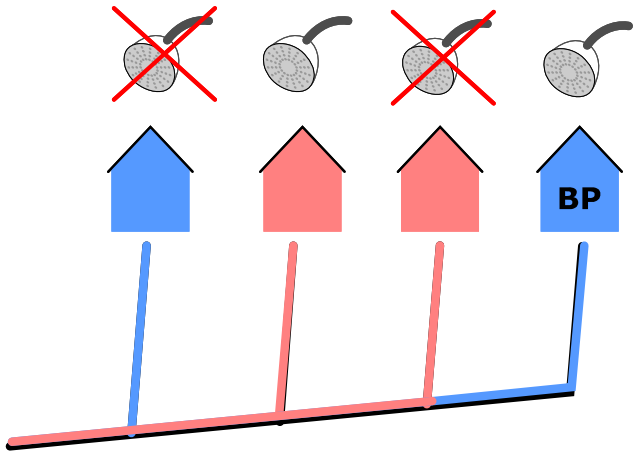
Bypass is only turned on when:

the water has become too cold.



Bypass control principles

- Constant mass flow
- Thermostat control
- **Predictive control**
- Perfect predictions
- Optimal bypass control

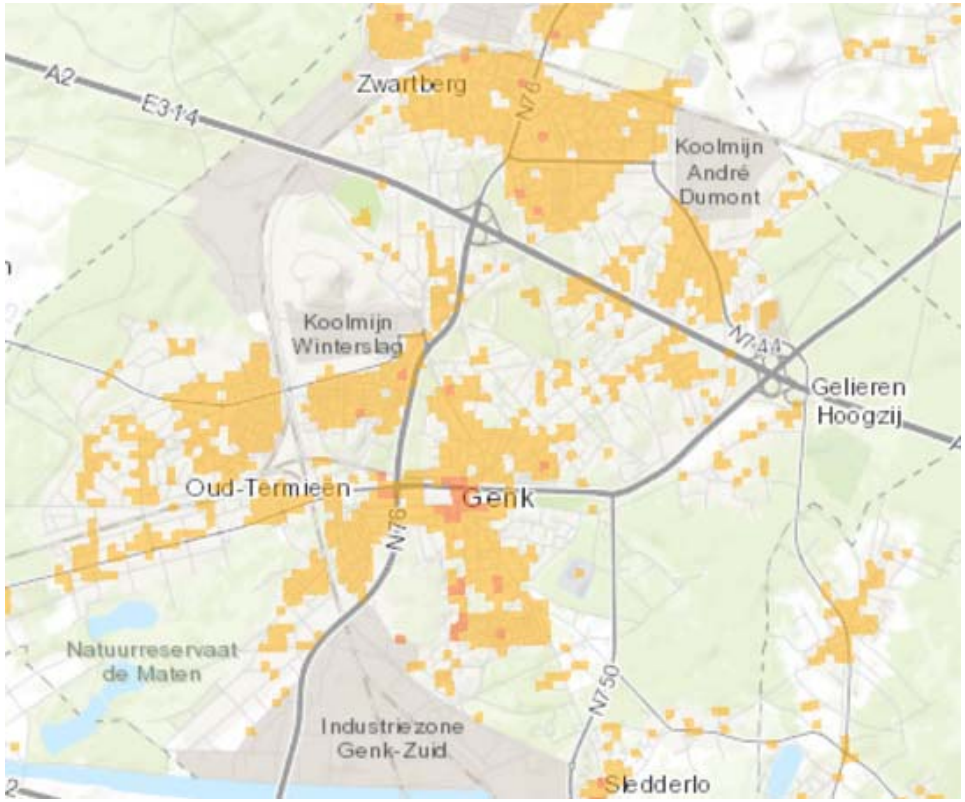


Bypass is only turned on when:

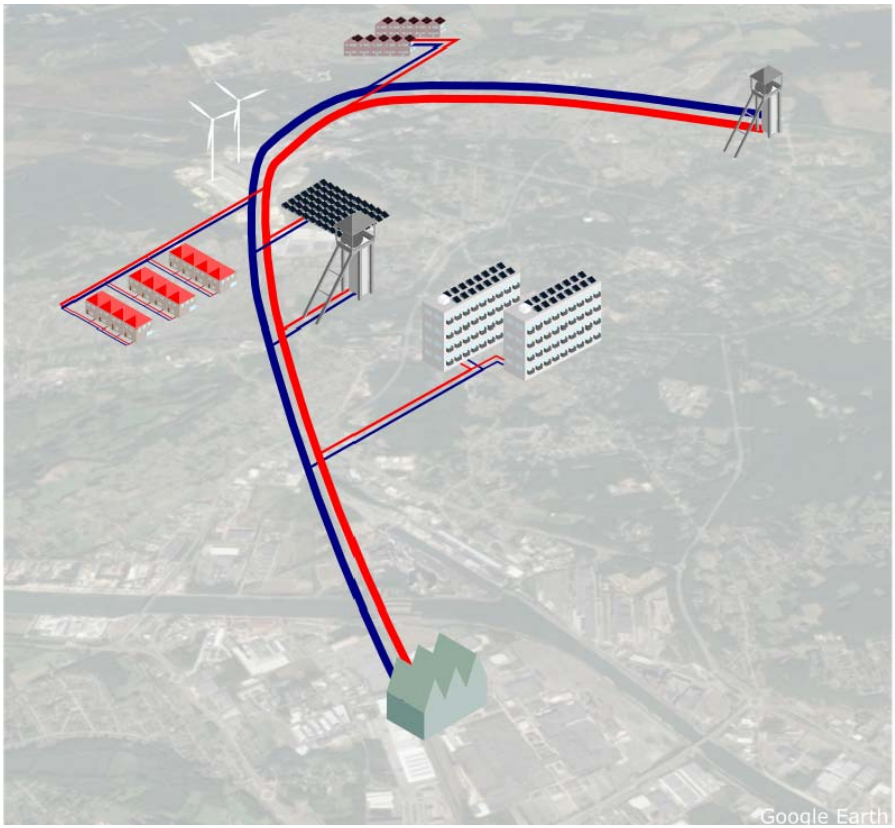
the water has become too cold,

and there will be a heat demand.

The Genk case

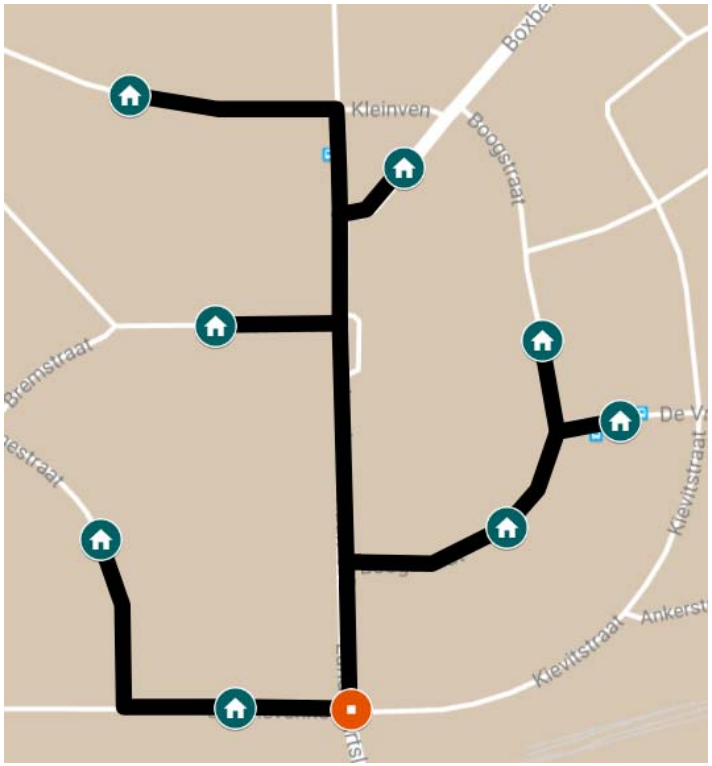


Heat RoadMap: http://www.heatroadmap.eu/Peta4.php



Methodology

- Simulation case of a small neighborhood
  - Boxbergheide in Genk, Belgium
  - 65 buildings
  - Network with T_{supply}=60°C

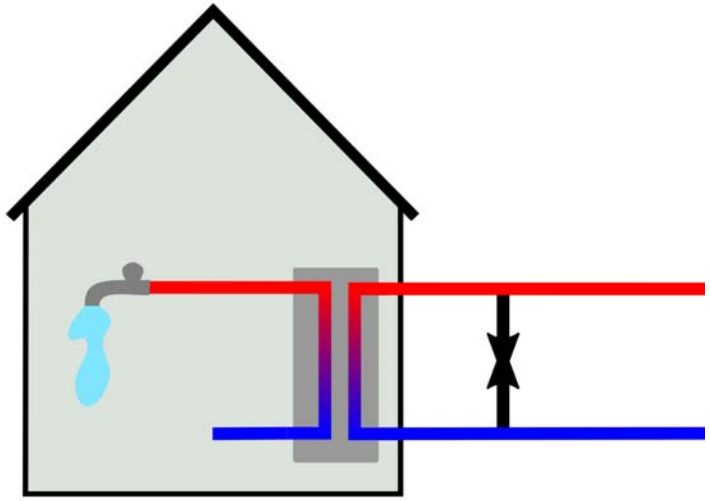


Google MyMaps

Simulation set-up

- Use of bypass pumps most frequent in summertime
  - No space heating required
  - No DHW tanks, direct delivery of DHW
- New open-source plug flow pipe models for the network

B. van der Heijde, M. Fuchs, C.R. Tugores, G. Schweiger, K. Sartor, D. Basciotti, D. Müller, C. Nytsch-geusen, M. Wetter, L. Helsen, Dynamic equation-based thermo-hydraulic pipe model for district heating and cooling systems, Energy Convers. Manag. 151 (2017) 158–169.

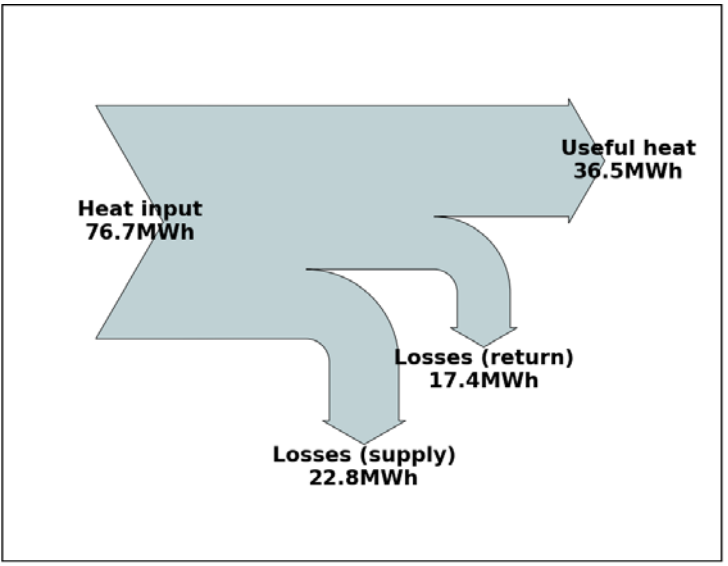


Results

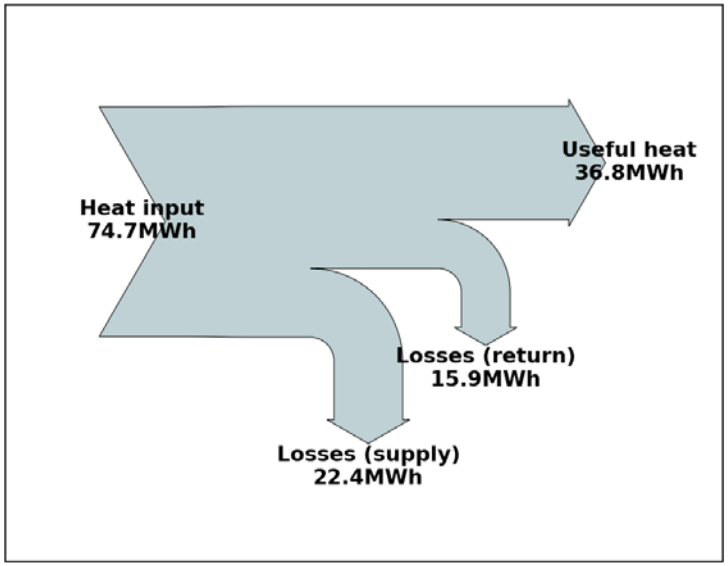
	System efficiency [%]	Average temperature difference [°C]	System overflow [m^3]
Constant mass flow	47.5	14	3081
Thermostat control	49	18	2138
Predictive control	57	35	384

Results

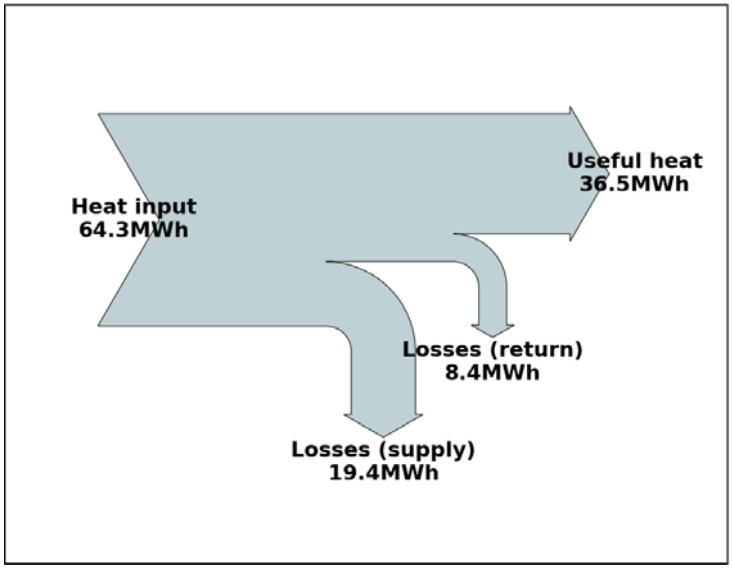
Constant mass flow



Thermostat control



Predictive control



Conclusion

- Control of bypass that used predictions and time delays works best
  - Perfect predictions: upper boundary for real cases
  - Time delays offer many possibilities

- Novelties:
  - Development of predictive control with time delays
  - Comparison of bypass controllers at system level

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