Energy Institute Hrvoje Požar

District heating as the thermal storage – support to the power system with potential for a higher integration of RES

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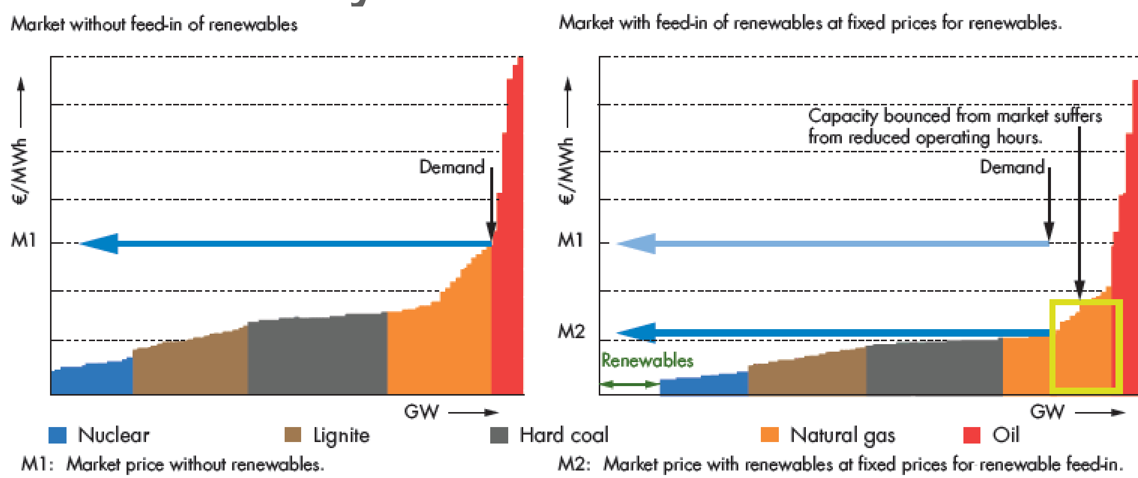
International Conference on Smart Energy Systems and 4th Generation District Heating
Copenhagen, 25-26 August 2015

4th Generation District Heating Technologies and Systems

Introduction

- Energy – *conditio sine qua non*
- 46 % of total final energy for heating&cooling (IEA)
- CHP + DH → more appropriate way of fuel usage
- Fast bond between production of heat and electricity in conventional CHP-DH systems
- Unfavorable design of electricity market (*merit order*)
- Increased share of RES



Source: graphic EnBW, VGB, www.vgb.org

Motivation

- Future consequences:
  - Reduction of *Capacity factor*
  - Frequent load change
  - Gaining opportunity costs
  - Operation in economically not justified conditions

Requirements for:
- **Heat storages**
- Lowering of the minimal load factor
- New design of electricity market?

Main idea: DH system as a heat storage

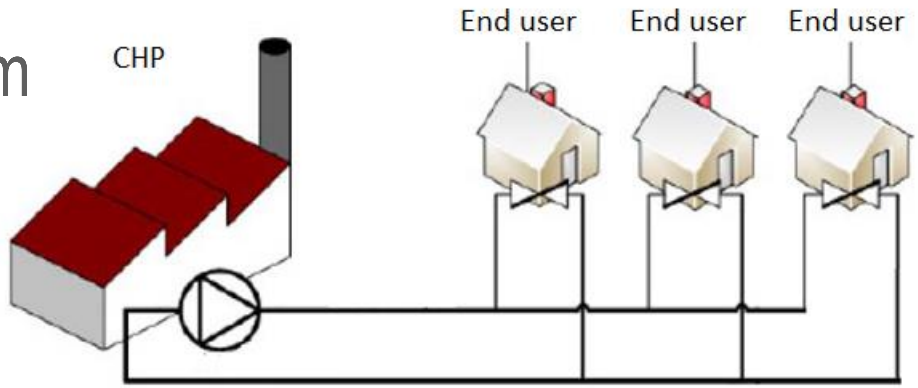
Increase in flexibility, provision of control power (Ancillary services), gaining additional revenue

DH system as the dynamical heat storage

- Decoupling the bond between H&E production
- Flexibility increase
- Maintaining the stability of the power system
- Dynamic analysis of the system (thermal inertia, energy accumulation)
- Lots of transient phenomena (e.g. pressure vs. temperature)
- The conducted research is based on the theoretical cases

Assumptions & simplifications

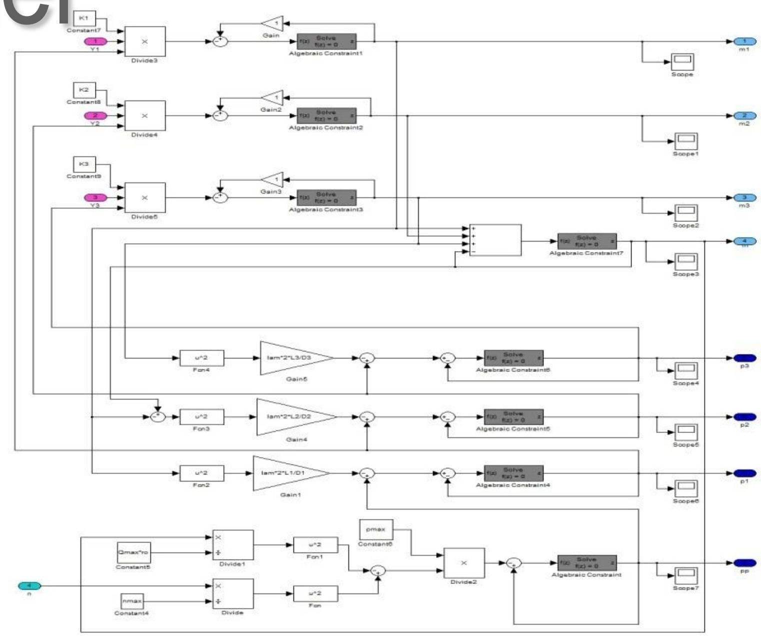
- DH system:
  - Long pipeline – max. 9000 m
  - 3 final users of the same characteristics
  - Type: direct



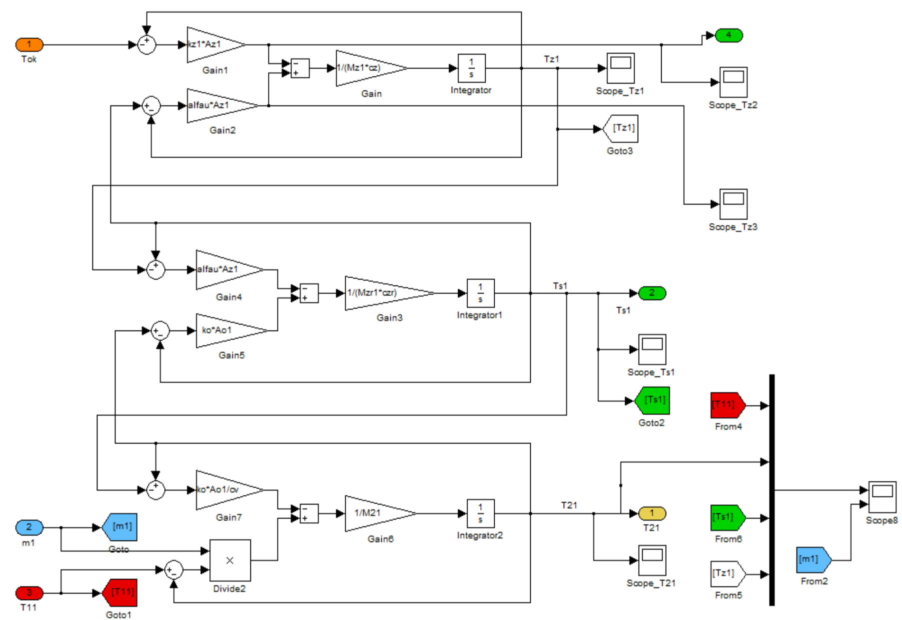
- Quasi-static mass flow
- Accumulation capability: pipeline mass taken into consideration
- Thermodynamic properties of the water $\neq$ *f(T,p)*

Mathematical model

- Hydraulic model:
  - Mass flows & pressure drops
  - 8 algebraic equations

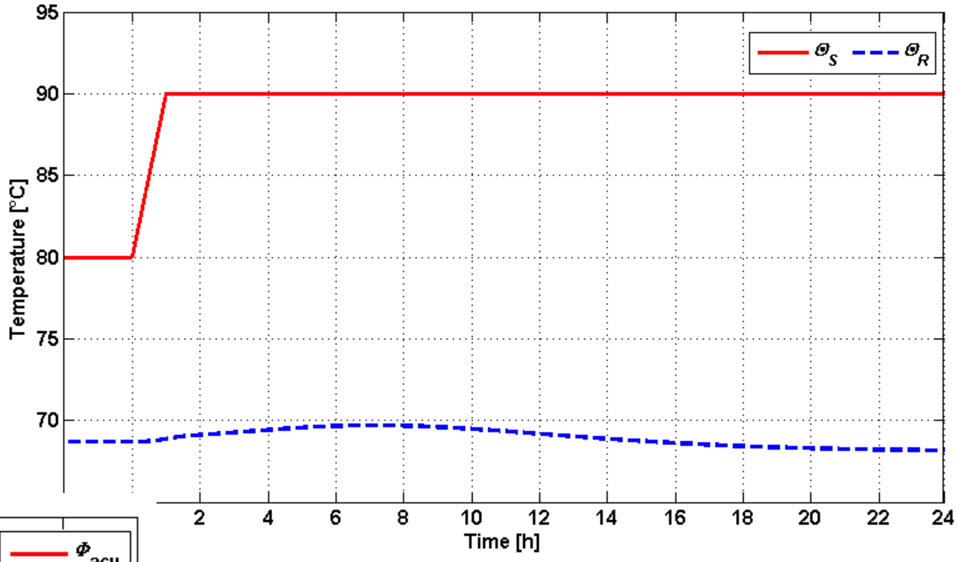


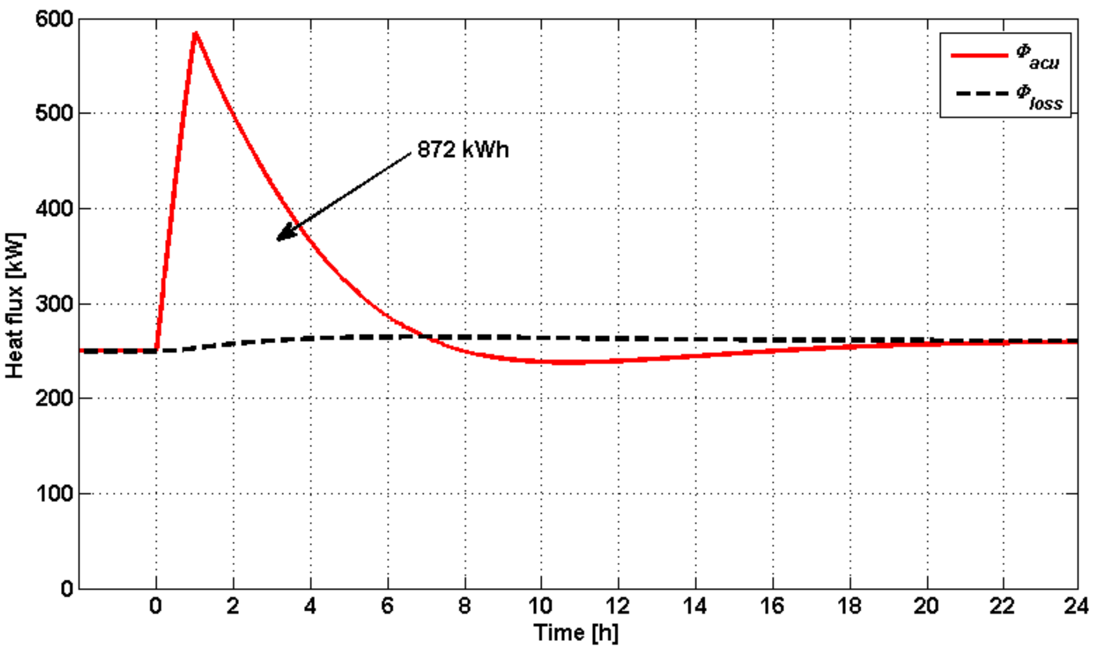
- Thermodynamic model:
  - Temperatures & heat fluxes
  - 21 differential equations
  - 2 algebraic equations



Simulation results

- Accumulation capability
  - Input disturbance
  - System response

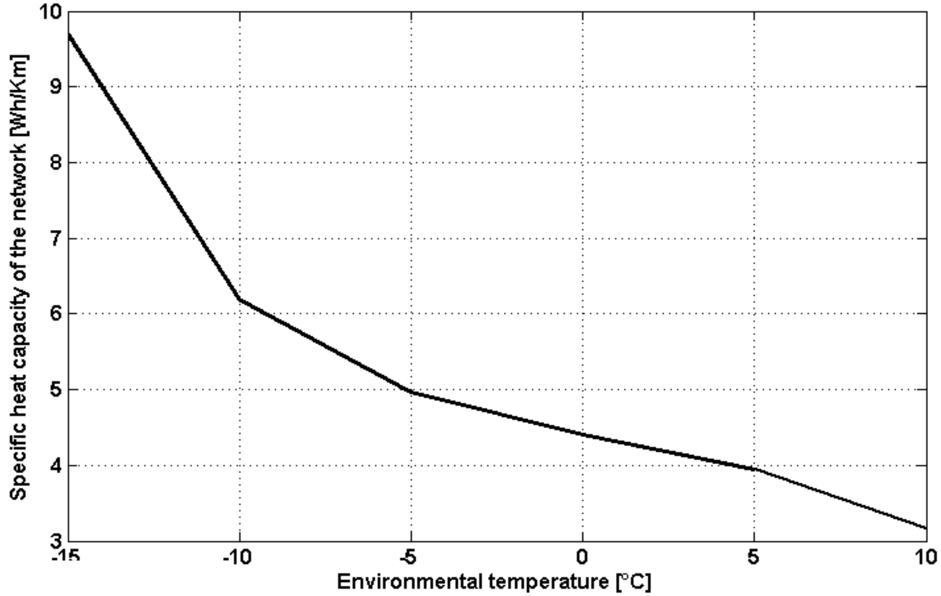




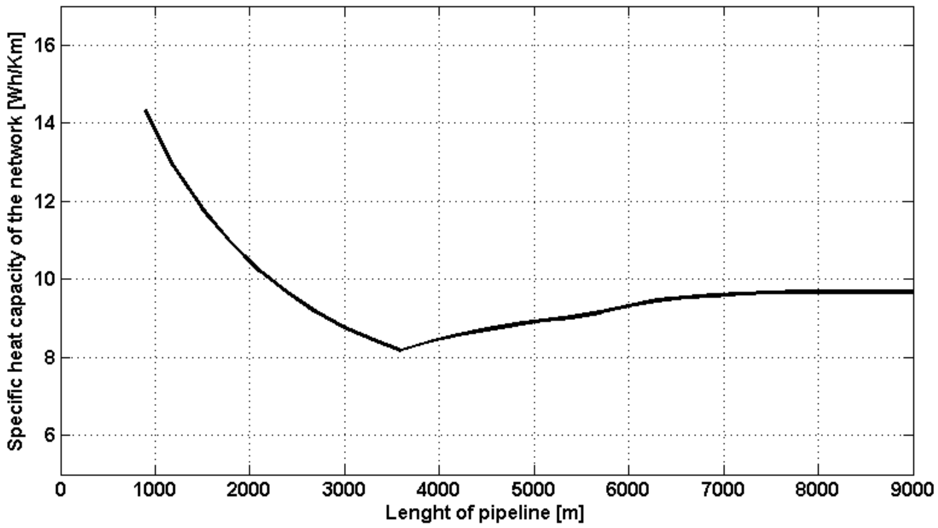
$$L_{DH} = 9000\ m$$
$$\vartheta_E = -15°C$$

Simulation results

- Specific heat capacity of the network
  - Impact of network length
  - Impact of environmental temperature



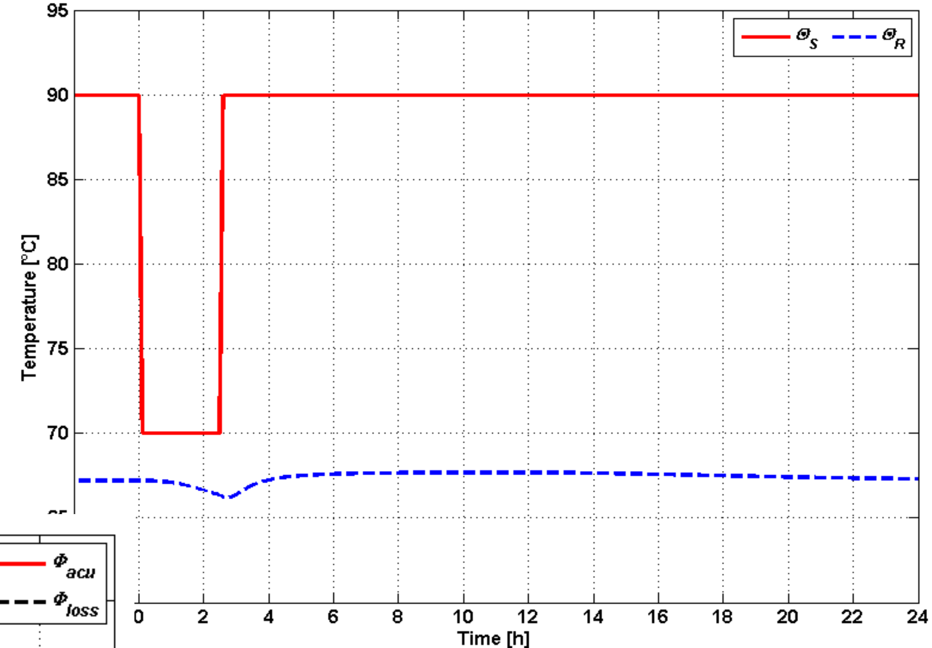
$L_{DH} = 9000\ m$

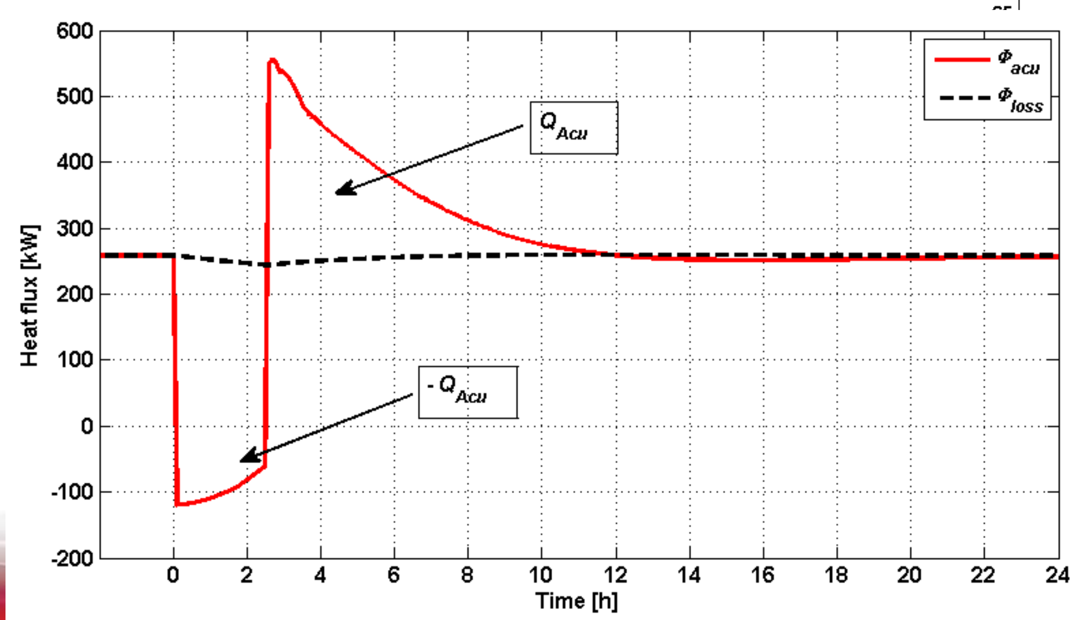


$\vartheta_E = -15°C$

Simulation results

- Temperature drops of the supply water
  - Input disturbance
  - System response

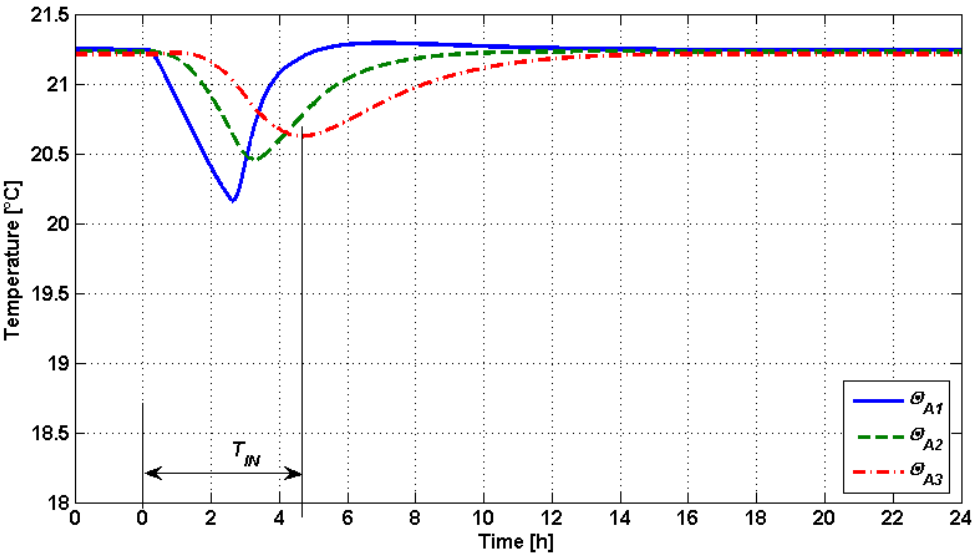




$$L_{DH} = 9000\ m$$
$$\vartheta_E = -15°C$$

Simulation results

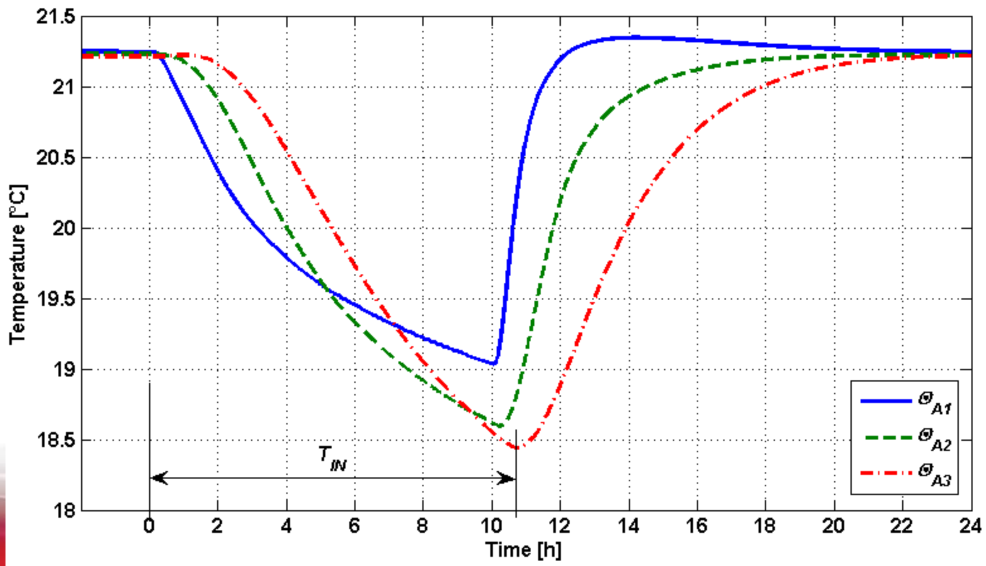
- Temperature drops of the supply water
  - Impact on the ambient air temperature



$\Delta t = 2.5h$

$L_{DH} = 9000\ m$

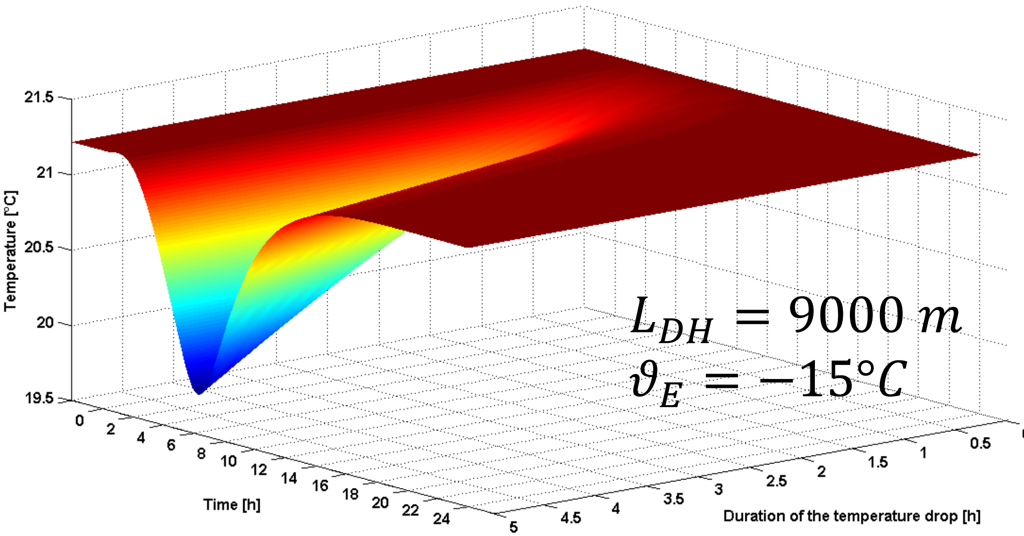
$\vartheta_E = -15°C$



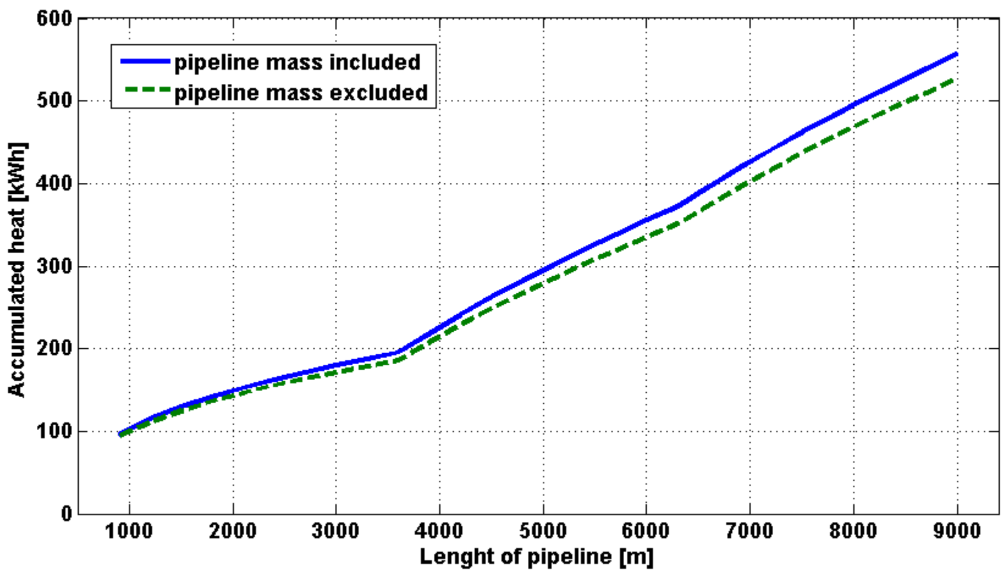
$\Delta t = 10h$

Simulation results

- Temperature drops of the supply water
  - Impact on the ambient air temperature



- Impact of the pipeline mass on the accumulation capability



Conclusion

- DH systems – great time constants → Heat storage
- Dynamic analysis
  - Heat demand vs. Heat storage capacity
  - Impact of the duration of disturbance on the end user's comfort
  - Flexibility → Control power (ancillary services)
- Economic analysis neglected
- Starting point for the optimization

Thank you for your attention

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