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

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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

Main idea: DH system as a heat storage

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

Requirements for:
- Heat storages
- Lowering of the minimal load factor
- New design of electricity market?
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 $\neq f(T,p)$
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

\[ L_{DH} = 9000 \, m \]
\[ \vartheta_E = -15^\circ C \]
Simulation results

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

\[ L_{DH} = 9000 \, m \]

\[ \vartheta_E = -15^\circ C \]
Simulation results

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

\[ L_{DH} = 9000 \, m \]
\[ \vartheta_E = -15^\circ C \]
Simulation results

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

\[ L_{DH} = 9000 \, m \]
\[ \vartheta_E = -15^\circ C \]

\[ \Delta t = 2.5h \]
\[ \Delta t = 10h \]
Simulation results

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

- Impact of the pipeline mass on the accumulation capability

\[ L_{DH} = 9000 \text{ m} \]
\[ \vartheta_E = -15^\circ C \]
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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