FLEXIBILITY IN DISTRICT HEATING SYSTEMS

A suitable definition and model to describe the temperature and energy flexibility

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Challenges with renewable generation
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Base load generator

Annual heat demand and geothermal generation (power)
Challenges with renewable generation

Availability not synchronous with demand

Daily heat demand and solar generation (power)
Definition of flexibility

Flexibility: “Easily changed to suit new conditions”
(Oxford Dictionary)

Flexibility is not fixed to a physical quantity.
→ It is a property of a chosen physical quantity.

Energy Flexibility is “the ability to modify energy generation or consumption of a system in response to external [...]” [conditions]
(Fischer et al.: “Model-based flexibility assessment of a residential heat pump pool”, Elsevier Energy, 2016)
Typical flexibility model in thermal systems

(Nuytten et al.: “Flexibility of a combined heat and power system with thermal energy storage for district heating”, Elsevier Applied Energy, 2013)
Example model in electrical systems

Problem of existing thermal models

Flexibility in thermal systems should include **quantity AND quality** of energy

= energy and temperature
Flexibility definition in production systems

Flexibility theory is used in production systems for more than 40 years.

Definition: "Adaptability of production systems to changing responsibilities"
(Hans Corsten: „Produktionswirtschaft“; Oldenbourg; Munich 1996)

Flexibility in quantity of products

Flexibility in quality (state) of products


(Steve Jurvetson: “Tesla Autobots”; CC BY 2.0 Licence; https://www.flickr.com/photos/44124348109@N01/6219463656, 12/11/2018)
Opportunistic coordination in production systems

**Principle of opportunism**
- Consider all degrees of freedom
- Detecting all alternatives
- Resource-capacity
  - „Smart“ system: knowledge of subsystem’s potential
  - No early data aggregation: separated planning of temperature and energy

**Principle of least commitment**
- Point of time to decide
  - Time based: latest point of time with least loss of flexibility
  - Content: most flexible alternative
  - Use the most economical flexibility

(Hans Corsten: „Produktionswirtschaft“; Oldenbourg; Munich 1996)
The Energy and Temperature Flexibility of District Heating Systems is the ability to modify energy and temperature level of generation or consumption in response to external conditions.
Flexibility model

Flexible temperature

Flexible mass flow

Discrete flexibility block

Energy

Power
## Categories of flexibility

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<th>Seasonal flexibility</th>
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<td>• Biomass boiler</td>
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<td>• Intelligent HVAC</td>
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<td>• Digital radiator valves</td>
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</tbody>
</table>

- **Different volumes**
- **Different temperatures**

- Chemical / biomass (primary energy)
  - Biomass boiler
- Air and building mass (demand side)
  - Intelligent HVAC
  - Digital radiator valves
Time horizons in district heating systems

**Long term planning**
- Average system temperatures
- Frequency: 1 a
- Scope: >10 a
- Interval: 1 d

**Day ahead planning**
- Forecasted temp.
- Frequency: 1 d
- Scope: 14 d
- Interval: 1 h

**Intraday planning**
- Interaction of temperatures
- Frequency: ¼ h
- Scope: 1 d
- Interval: ¼ h

**Long term planning**
- Investments
- Customer contracts

**Day ahead planning**
- Seasonal storages
- Raw material trading
- Ecologic KPIs

**Intraday planning**
- Integration of temperature flexibility
- Integration of customer-plant
- Prices for temperature levels

**Day ahead planning**
- Interaction with electrical markets
- High forecast accuracy

**Intraday planning**
- Seasonal storages
- Raw material trading
- Ecologic KPIs

**Long term planning**
- Investments
- Customer contracts

**Day ahead planning**
- Seasonal storages
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**Intraday planning**
- Integration of temperature flexibility
- Integration of customer-plant
- Prices for temperature levels
Requirements to Smart Thermal Grids

- Flexible quantity and quality of energy: Energy and Temperature
- Energy flexibility has 3 dimensions: mass flow, temperature and time
- Principle of opportunism: Smart thermal grid (measurement & actors)
- Principle of last commitment: Use the most economical flexibility
- Different planning horizons for energy and temperature

→ Detailed optimization and trading becomes possible
Thank you for your attention!

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→ Find “Smart Heat Grid Hamburg” on youtube!