Intelligent concepts for construction and flexible operation of district heating systems based on measurement and simulation to increase the integration of more renewable energies in electric and heat generation

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Motivation

German Goals of the energy-turnaround until 2050

Electricity:

80 % Generation from renewable sources

Wind and PV cause big fluctuations in electrical generation

Buffering by coupling with heat-sector

Heat:

80 % Reduction of primary energy

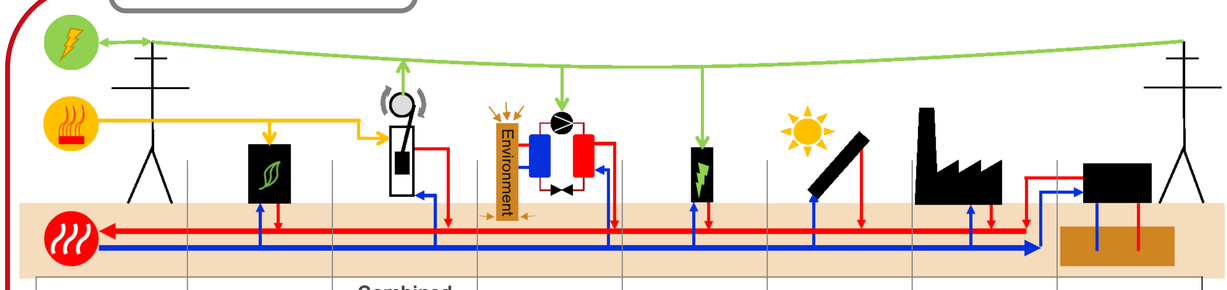
Increase of efficiency by CHP-processes

Reduction of heat demand

Expansion of renewable heat generators

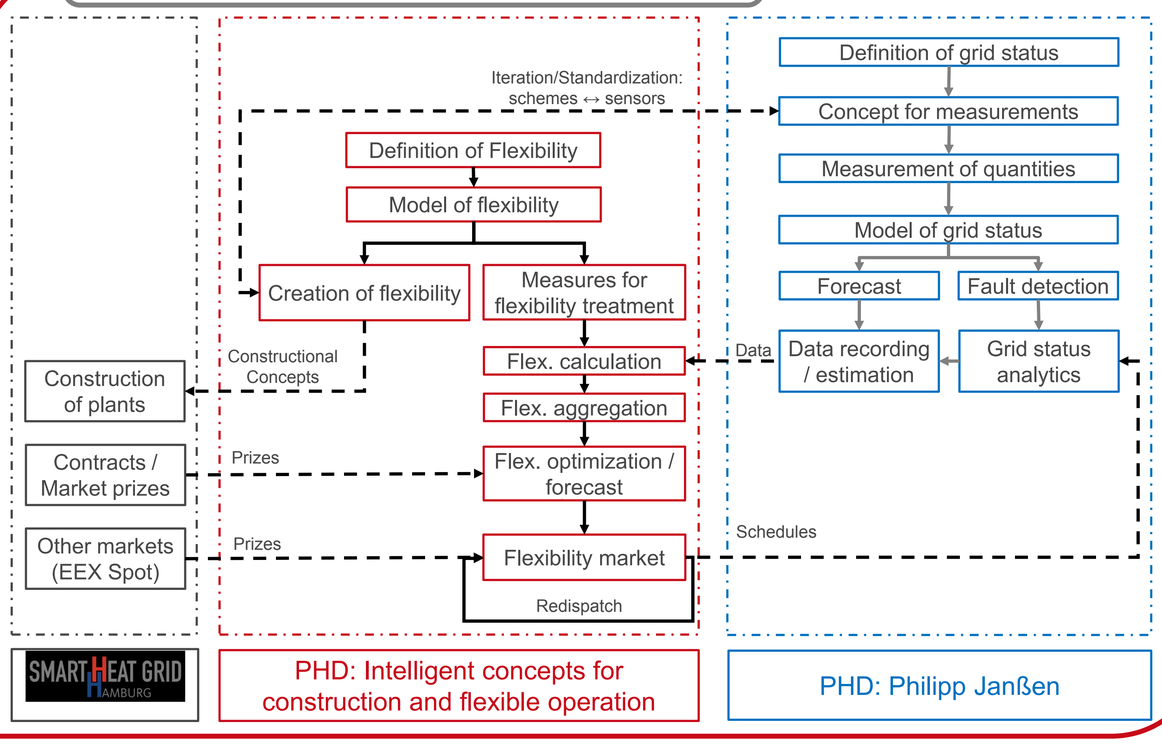
Needs of a flexible and efficient heat-sector

Background



	Biomass	Combined heat and power	Heat pump	Electrical heating	Solarthermal	Industrial waste heat	Geothermal
Source	Bio fuels	(Bio) Methane	Electricity + environment	Electricity	Solar radiation	Waste heat	Geothermal energy
Technical restrictions	Fuel availability, transport, area demand	Efficiency, less starts	High performance factor in case of low temperatures	Low performance factor	Availability vs. demand	Process interaction, availability	Base-load operation, part load modulation, no starts
Economical restrictions	Low investments, high variable costs	Coupled to electricity and gas-market	Higher investments, lower variable costs than p2h	Low investments, high network charges	Low operation costs	High investments, low variable costs	High invest, low variable costs

Objectives and dependencies



Definition and model

Definition

1. Energy flexibility [of a thermal system] is “the ability to modify energy generation or consumption of a [thermal] system in response to external signals“ [1].

2. Temperature flexibility of a thermal system is the ability to modify the temperature level of generation or consumption of a thermal system in response to external signals (without changing the amount of energy generation or consumption).

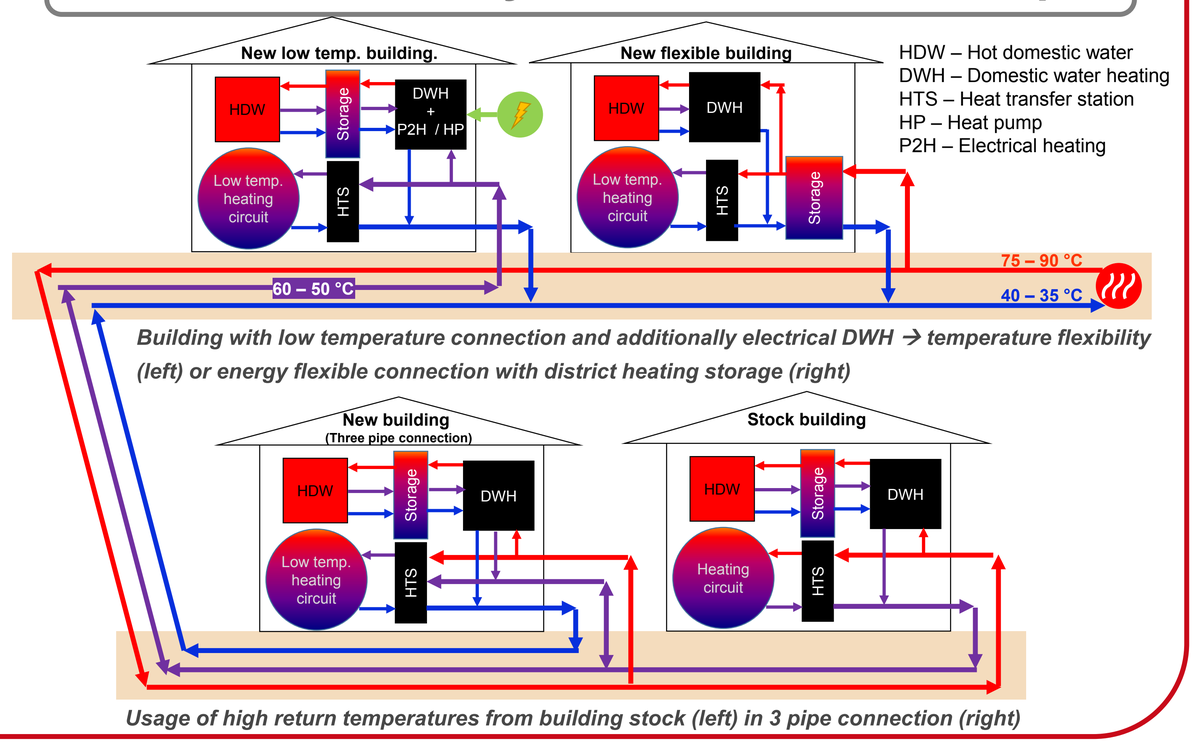
3. Energy and temperature flexibility of a district heating system is the aggregated ability to modify the amount of energy and the temperature level of generation and/or consumption of thermal subsystems connected to a district heating system in response to external signals.

[1] David Fischer, Tobias Wolf, Jeannette Wapler, Raphael Hollinger, and Hatef Madani. Model-based flexibility assessment of a residential heat pump pool. Energy, 2016. ISSN 0360-5442. doi: http://dx.doi.org/10.1016/j.energy.2016.10.111. URL http://www.sciencedirect.com/science/article/pii/S0360544216315572.

Model

- Three dimensions: temperature (quality), mass flow (amount) and time
- Discrete in every dimension
- Time horizon: 10 years, 1 year, 1 week, 1 day, 15 min, (real-time)
- For each component (pump, valve, storage, …): minimum and maximum for each dimension
- Aggregation of component flexibility to subsystem and district heating flexibility

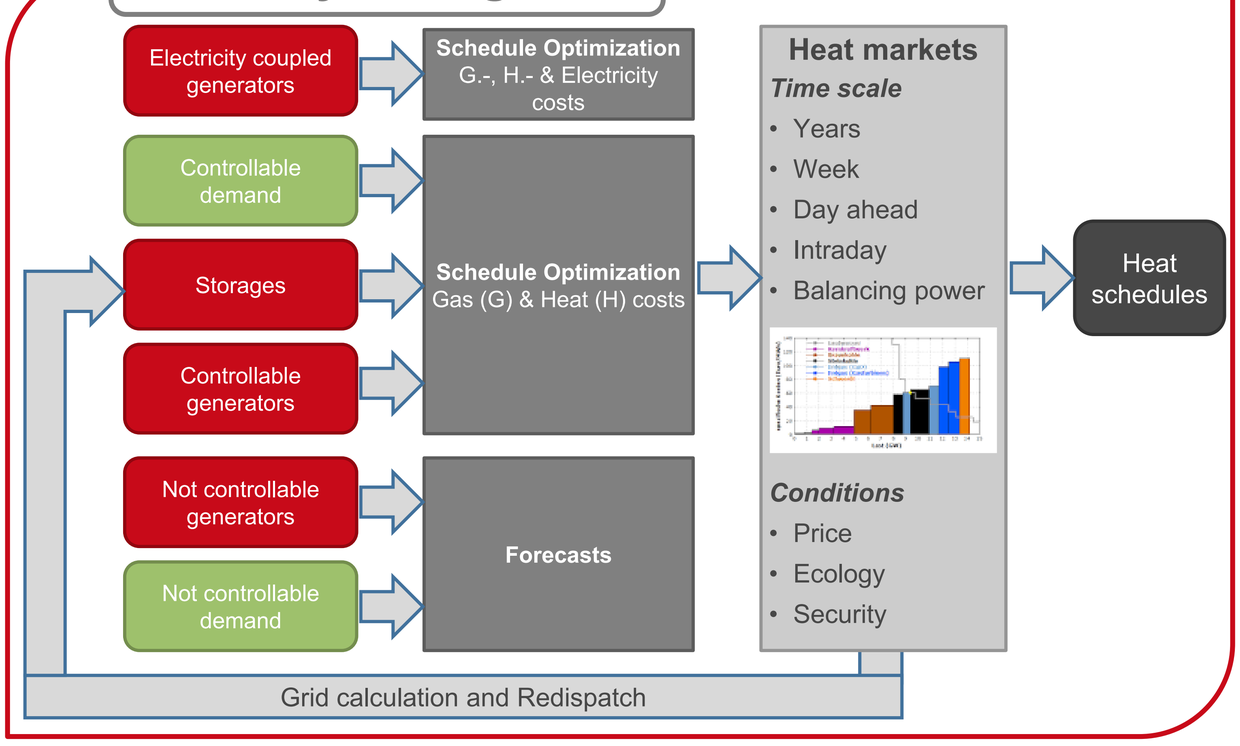
Creation of flexibility → constructive concepts



Building with low temperature connection and additionally electrical DWH → temperature flexibility (left) or energy flexible connection with district heating storage (right)

Usage of high return temperatures from building stock (left) in 3 pipe connection (right)

Flexibility management



Side aspects

- **Acquired Project “Smart Heat Grid (SHG) Hamburg”,** BMWi, 3,5 Mio. €, 4 years, 3 Partner (HAW Hamburg, Hamburg Energie GmbH and eNeG) **including one additionally PhD-Thesis**
- **Next project application “Smart proHeat” in cooperation with Aalto, Finland, including two possible new PhD-Theses**
- **Beginning of a new research focus “smart and renewable district heating” at the Energiecampus Hamburg**

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