Karlsruher Institut für Technologie

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Start: from now on **Duration:** 6 months

☐ Experiment ☒ Application ☒ Theory

YOUR interests:

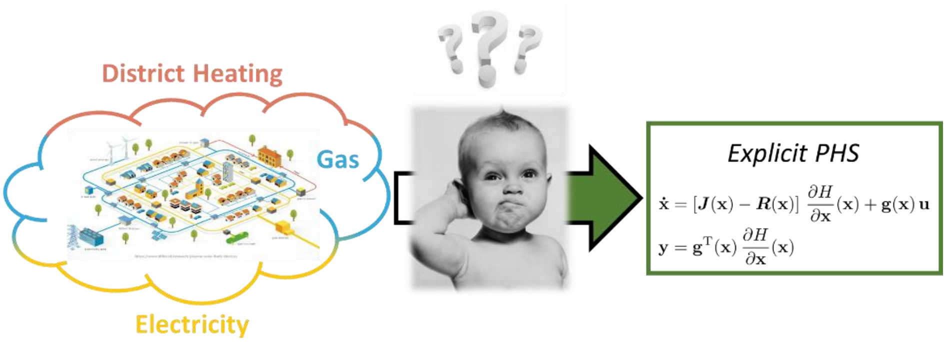
Generalized modeling, system theory (Lyapunov stability, passivity)
advantageous, but not necessary: fluid mechanics/thermodynamics

Master's Thesis

Modeling of Gas and District Heating Grids for Plug-and-Play Control Design

Motivation:

Multi-carrier energy distribution systems (MEDSs) coupling electricity, district heating, and gas distribution networks, are a major means to provide the necessary flexibility for integrating a high share of renewables. However, their holistic operation and analysis requires **generalized models across the different domains** (cf. "Modellbildung & Identifikation"). Furthermore, **plug-and-play** capability is a key operational feature to handle the large number of dynamically interacting units. It allows for disconnection/connection of units without adapting controllers, communicating, and endangering stability. At the IRS, first research results in the electrical domain have been obtained using **port-Hamiltonian system (PHS)** models [1, 2]. Due to their energy-based nature and their link to passivity theory and thus Lyapunov stability, PHS models are also a promising starting point for the largely unexplored MEDS case.



Objectives:

The main goal of the thesis is the generalized, energy-based modeling of gas and district heating grids for subsequent plug-and-play control design. At first, a literature research on existing models with focus on control design is to be conducted. In the main part of the thesis, the findings should be used to derive generalized, energy-based control design models for the relevant components in each domain (gas, heat). Of particular interest is the streamlining of parallels between the different domain models and a passivity analysis. Furthermore, the models should be related to graph theory and bond graphs to allow a formal, graph-based system description. Afterwards, two foci are possible: 1) modeling of a real multi-carrier energy system (electricity, heat, gas) within the RegEnZell project; 2) formulation of the plug-and-play control problem for multi-carrier energy systems ("What should be controlled?") based on the model knowledge.

[1] Strehle et al. (2019): *A Port-Hamiltonian Approach to Plug-and-Play Voltage and Frequency Control in Islanded Inverter-Based AC Microgrids*

[2] Strehle et al. (2020): *A Scalable Port-Hamiltonian Approach to Plug-and-Play Voltage Stabilization in DC Microgrids*